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SUSINI'S ETHER ENGINE.

WE represent herewith two types of the Susini ether engine constructed at the works of Mr. Digeon. The idea of replacing steam as a motive force by the vapor of a liquid boiling at a low temperature has attracted the attention of very many investigators; but in the putting of this idea into practice, they have all met with difficulties that seemed insurmountable, and that were principally connected with leakages at the joints of the engine that occasioned great losses of ether, and with the condensation of the vapor in the cylinder before producing its useful effect. It is the suppression of this inconvenience that constitutes, properly speaking, Mr. Susini's invention and marks the first step in a path which, in the inventor's opinion, must end in a complete revolution in the construction of the steam engine, and principally in that of marine engines. In fact, the use of a liquid capable of being converted into vapor at a low temperature, and of being regenerated without loss after the work of the same, makes it possible to entirely suppress water as a generator, and consequently to lighten boats and locomotives, and prevents one of the principal sources of accidents due to the use of steam—we mean boiler incrustation. It is especially from these two points of view that we, for the moment, are regarding the importance of this invention. The question of economy requires, in fact, a long series of observations which have not as yet been made in a sufficiently complete manner.

Let us state, however, that in the installation represented in Fig. 4, in which the ether engine is operating simply through the utilization of the heat of the exhaust of a vertical compound steam engine, it has been found possible in experiments made in the last month of the year 1890 to obtain a sensible saving in fuel, due to the complete utilization of the heat of condensation of the steam, and which was previously lost, inasmuch as the engine worked with free exhaust.

We shall give a description of the ether engine represented in Figs. 1, 2, and 3, and which may be considered as the type that the inventor proposes for replacing the present marine engines.

The motor is horizontal and has four single-acting cylinders united in pairs, and is entirely inclosed in a cast-iron chest, B (Fig. 3), containing glycerine. This part of the engine presents no remarkable peculiarity, and in Fig. 1 we do not show a section of the motor, since it would have unnecessarily complicated the engraving. The interesting feature of the system resides entirely in the generator placed under the engine, and the general arrangement of which is shown in Fig. 1. It consists of two horizontal heating tubes, K and K' (Fig. 1), connected by a bundle of curved tubes leading the ether and completely surrounded by a cylindrical iron-plate jacket, C, filled with water, forming a thermo-siphon that effects the distillation of the ether. Above this jacket there is a receptacle, D, containing the glycerine, and which is provided with a series of pendent tubes that enter the water of the said thermo-siphon. The glycerine, becoming heated in the tubes, rises to the surface, circulates all around the motor and returns to the lower part in order to perform the same journey indefinitely. It will be seen that the tubes and the receptacle as a whole constitute a second thermo-siphon heated by the first.

The vapor of ether reaches the motor through the tube figured to the right of the engraving, and which is surrounded by a second tube containing water at the lower part and glycerine at the upper, and which prevents condensation of the vapor before it has acted upon the pistons. A metallic cut-off traversed by the ether conduit prevents the mixing of the water and glycerine in the heating tube.

The motor and the pipe that leads the vapor of ether are therefore completely surrounded with glycerine, the temperature of which is always kept sufficiently high to prevent condensation. Moreover, as the glycerine has no affinity for ether, the latter, in case of a leakage, would remain imprisoned above the glycerine. Finally, as the glycerine is an excellent lubricator, the lubrication of the different parts of the motor is effected automatically and more perfectly than in the ordinary system of lubrication.

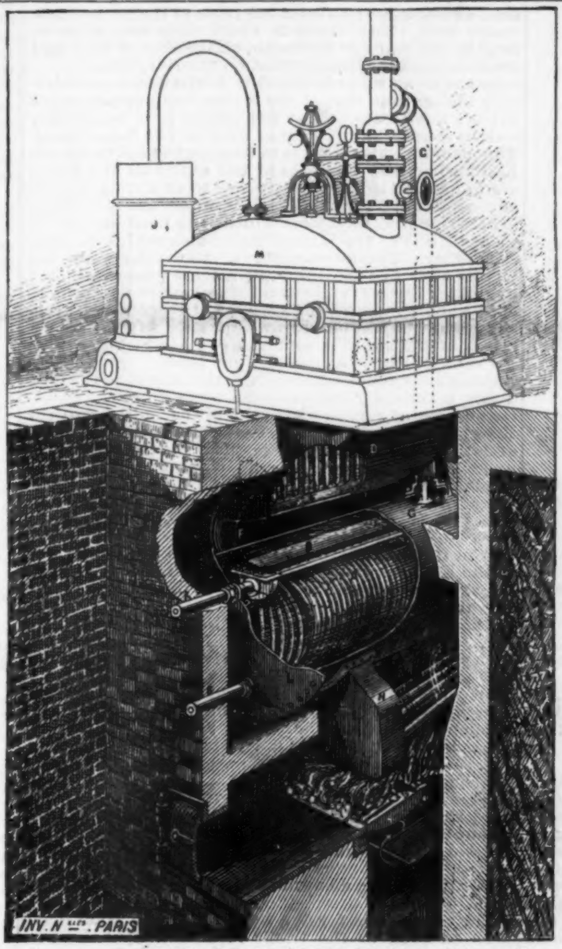


FIG. 1.—SECTION OF SUSINI'S ETHER ENGINE.

On making its exit from the cylinders, the ether vapor goes to an aero-condenser, C, which constitutes one of the essential parts of the system, and which is represented in section in Fig. 2.

It consists of a bundle of vertical tubes, J, contained in a cylinder, N, and debouching at their two extremities in the chambers, K and L. The chamber above receives the conduit, K, of a blower actuated by the engine. The lower chamber receives the conduit through which is expelled the air that has traversed all the tubes. This conduit is figured in dotted lines at the base of the apparatus.

The ether enters the cylinder N through the pipe A, and becomes condensed in contact with the tubes cooled by the current of air which is humidified by means of an atomization of water effected at O through the meeting of small convergent jets issuing from a series of small capillary tubes, *p*. A back, P, holds the water to supply these tubes, and it is the pressure of the current of air coming from the blower and entering the back through the apparatus, *q*, that causes the water to rise in the tubes, *p*, and to spurt in convergent jets that come into collision at O. The atomized water is carried along in the tubes J by the current of air and thus notably increases its refrigerant power. The condensed ether collects at the lower part of cylinder N and flows through the tube B, in order to return to the generator, thus forming a complete and, so to speak, indefinite cycle.

It remains for us to say a few words as to the installation shown in Fig. 1. Here the inventor does not have recourse to direct heating in order to produce the volatilization of the ether. His object has been to show, as we have already said, how easy it is, with an ether motor placed in the vicinity of a steam engine with free exhaust, to utilize the heat of condensation of the steam for actuating the ether motor and thus obtaining, gratuitously, as it were, a notable increase of motive power.

The steam engine is represented to the right of the engraving. It receives steam from a vertical boiler seen at the left, outside of the building. After operating in the cylinders, the steam flows through the curved pipe into a condenso-generator formed of a series of vertical tubes inclosed in a cylinder containing ether. The steam at once condenses in these tubes, and the heat that it gives up is sufficient to develop vapor of ether at a pressure of three atmospheres, which operates in a small motor, like the one that we have described, and afterward returns and is condensed in the aero-condenser, whence the ether returns to the generator.

This interesting application of the ether motor is capable of rendering great services in works which, by reason of the increase of the number of tools operated by the steam engine, or as a consequence of the installation of electric lighting in the shops, have need of a motive power greater than that furnished by the said engine. Instead of having recourse to the always costly installation of a second engine and new boilers, there will be found in the ether engine the motive power sought for, and that, too, without any increase in the production of steam and consequently in the output of fuel.

As we have already said, the inventor, in devising the motor shown in Fig. 3, has had in view the replacing of the marine engine. For steamboats, and especially for vessels of war, there would be, in fact, a considerable advantage in the suppressing of the supply of fresh water necessary to feed the boilers. Torpedo boats, as well known, are not of sufficient dimen-

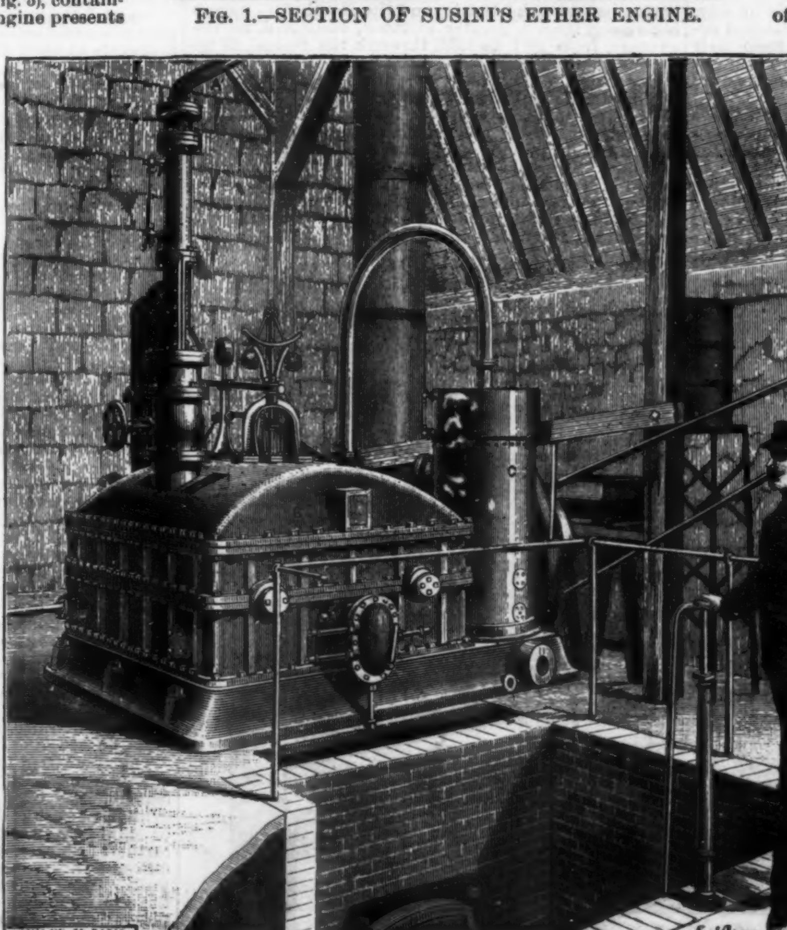


FIG. 3.—GENERAL VIEW OF THE ETHER ENGINE.

sions to allow of the installation of reservoirs or of apparatus for distilling salt water, and are obliged to feed the boilers with a mixture of salt and fresh water, the effects of which are disastrous as regards the preservation of the generators. A motor that would permit of suppressing such inconveniences would therefore prove of considerable value to those small vessels which form an essential part of the naval armament of the present day, and which would probably assume still greater importance were this motor question solved.

Aside from this consideration, there is another one which may prove of importance at a given moment, and that is the possibility of putting the engines under pressure much more rapidly than with steam boilers.

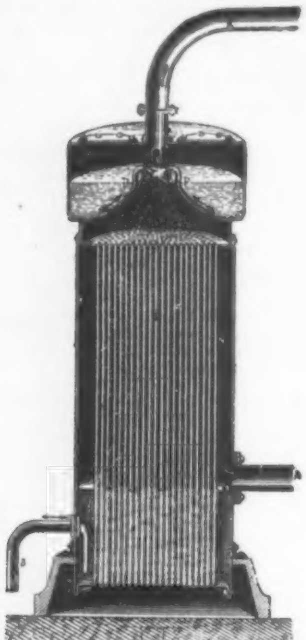


FIG. 2.—AERO-CONDENSER.

In fact, during the time that it takes to heat the water of an ordinary boiler to 100°, that is to say, to produce steam at one atmosphere, it will be possible, with an ether boiler, to obtain a pressure of 5 kilogrammes, which is suffi 'ent to allow a vessel to get under way.

It will be seen that in certain cases this would be a valuable advantage to war vessels, since, in case of an unexpected order to start, they would thus effect a valuable saving in time. But without speaking of such cases, how many times have not steam vessels, surprised by a tempest in a roadstead, after they had banked their fires, been beached because they were unable to get up pressure quickly enough to allow them to steam away before the gale. To cite but one case of this kind, we may mention the catastrophe at the Samoa Islands, in which three vessels of war, surprised by a tempest, were completely disabled because they had not taken the precaution to keep their fires lighted, while those which had kept up a slight pressure in the boilers had time to increase the pressure and reach the open sea.

It is probable that with a system that would have permitted them to get rapidly under pressure the ships that were afterward disabled would have escaped the catastrophe.

In conclusion, let us mention still another interesting application of the other motor proposed by the inventor. This is the construction of locomotives coupled with ordinary locomotives and utilizing the heat of the gases and steam which now escape through the smoke stack, and the production of ether vapor in a condenso-generator mounted upon the ether locomotive. The operation would be analogous to that of the system applied to the stationary engine and would afford the same advantages as regards economy.—*Les Inventions Nouvelles.*

THE SHIP CANAL BETWEEN THE NORTH SEA AND THE BALTIC.

THE cutting of the ship canal through the province of Schleswig-Holstein to connect the North Sea with the Baltic is progressing rapidly, and it is believed that it can be completed by April, 1893, or a little more than six years from the day on which the first spadeful of soil was turned in the presence of Emperor William I. at Holtenau, near Kiel. Since the sixteenth century sixteen plans have been urged for connecting the two seas, and the last two form the basis of the project now under way. The canal is about sixty-one miles in length, beginning at Holtenau, on the Bay of Kiel, and terminating near Brunsbuttel, on the river Elbe.

As the mean water level of the North Sea is considerably higher than that of the Baltic, both openings are to have huge locks. Near Rendsburg is to be another lock to connect the new canal with the old Eider Canal. The medium water level is to be about equal to that of Kiel harbor, and the locks at the outlet on the Baltic are to be open nearly always, or except during periods of considerable variations in the water levels. At the lowest tide the navigable width is to be about 119 ft., so as to allow the largest Baltic steamships to pass each other. The movements of war vessels and the largest vessels of the merchant marine were considered in making the curves, because they cannot pass a curve with a short radius. Between the two counter curves a straight line has been drawn for safe navigation. A speed of 5·3 knots is admissible. About sixty-three per cent. of the canal has straight lines.

From Holtenau to Rendsburg the line runs through a very undulating country, and there it has the greatest number of curves. In front of the outlet into the River Elbe is to be a roadstead. In cutting through about nine miles of the watershed of the rivers Elbe and Eider an excavation of about ninety-eight feet to the bottom of the canal is required. Between Rendsburg and the Baltic a ridge must be cut through, and just beyond Rendsburg the upper Eider lakes must be lowered for the canal to pass through. The flow of the canal is toward the Elbe, but at high tide in the Elbe it will discharge into the Baltic Sea. The banks are to have stone packing to diminish the force of waves.

About 7,000 workmen are employed in the construction. They are in 38 camps, of 100 to 500 men each, each camp having its own executive office and sleeping barracks. The common laborers get about seventy cents a day, and the foremen and skilled laborers get from ninety-five cents to $1.15 a day. The mechanical appliances are 27 dry dredgers, 24 floating dredgers, 87 locomotives, about 62 miles of track, 2,700 dirt carts, 4 elevators, 15 steamboats, 51 receptacles for dredging implements, and 37 steam pumps. Along the line are several forges and two brick yards. The total cost is fixed at about $37,128,000. About one-third of that amount was paid by the Russian Government before the work was begun. The rest is to be paid, as required, by the German Empire. The construction is under the management of the Imperial Canal Commission.

The regulations for the working of the canal have been adapted to the traffic to be anticipated. The traffic between the Baltic and the North Sea, including vessels from a greater distance, embraced, on the average, from 1871 to 1880, through the Sound, 35,246 vessels; through the belts, 4,000 vessels; through the Eider Canal, 2,258 vessels, or a total of 41,504 vessels. Of that traffic four-fifths, it is believed, may be counted on for the canal in the near future. About twenty-seven steam vessels and thirty tows of three to four sailing vessels, moving in one direction, can go through in a day. The time saved by a steamship running between Kiel and Hamburg by way of the canal is estimated at two days and a half. The time of the passage through the canal, including stoppages and delays, is to be about thirteen hours. Germany's naval ports at Kiel, on the Baltic, and at Wilhelmshafen, on the North Sea, can be within easy access after the completion of the canal, whereas now a squadron is three days from port to port.

Four railroads cross the line of the canal, but three of them are to be conducted over it by turnbridges, and one by a suspension bridge near Grunthal. For two of the much frequented country roads turnbridges are to be built, and for the others sixteen ferries are to be provided.

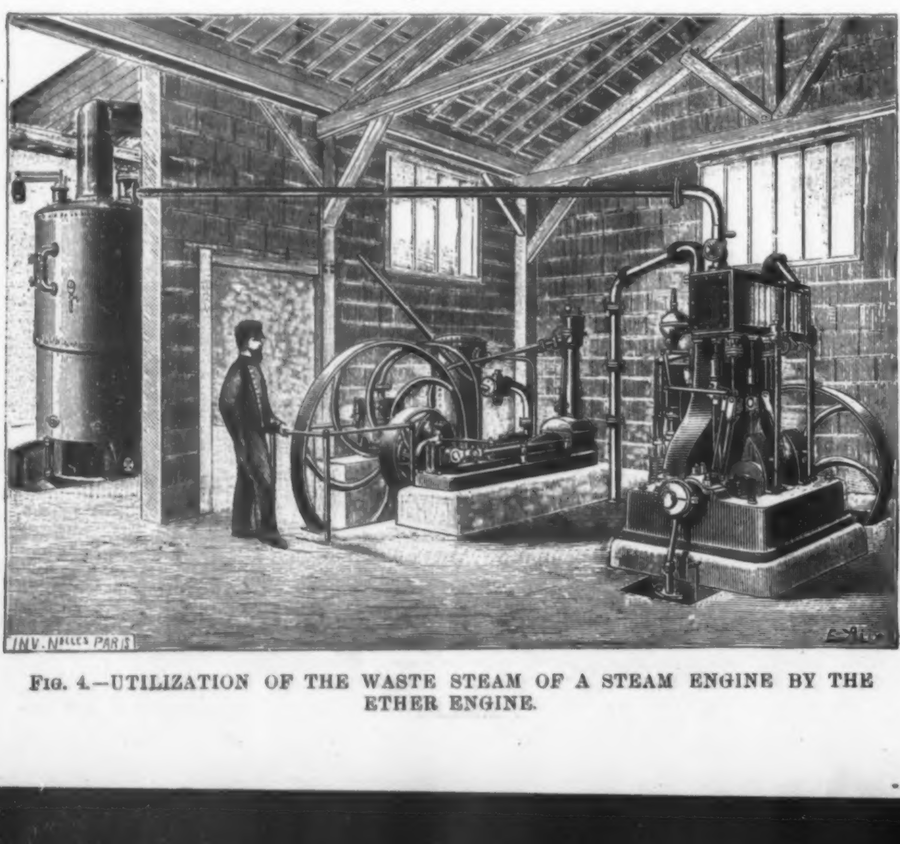


FIG. 4.—UTILIZATION OF THE WASTE STEAM OF A STEAM ENGINE BY THE ETHER ENGINE.

THE FORGING PRESS.*

By W. D. ALLEN.

IN the production of heavy forgings from cast ingots of mild steel it is essential that the mass of metal should be operated on as equally as possible throughout its entire thickness. When employing a steam hammer for this purpose, it has been found that the external surface of the ingot absorbs a large proportion of the sudden impact of the blow, and that a comparatively small effect only is produced on the central portions of the ingot, owing to the resistance offered by the *vis inertiæ* of the mass to the rapid motion of the falling hammer, a disadvantage that is entirely overcome by the slow, though powerful, compression of the hydraulic forging press, which appears destined to supersede the steam hammer for the production of massive steel forgings.

The press now brought under notice was designed to act more or less automatically, or self-acting, and to insure the perfect parellelism both of flat or square masses and of round shafts, without being dependent for their truth on the skill of the operator.

The forging press about to be described has been erected and in operation for some time. It works most satisfactorily, and, on the whole, is found to be a most efficient and useful tool.

In this press the force pump and the large or main cylinder of the press are in direct and constant communication. There are no intermediate valves of any kind, nor has the pump any clack valves, but it simply forces its cylinderful of water direct into the cylinder of the press, and receives the same water, as it were, back again on the return stroke. Thus, when both cylinders and the pipe connecting them are full, the large ram of the press rises and falls simultaneously with each stroke of the pump, keeping up a continuous oscillating motion; the ram, of course, traveling the shorter distance, owing to the larger capacity of the press cylinder.

The diagram, showing the press and pumps, is on the opposite page.

The top and bottom portions of the framing A A are alike, and from the same pattern, each consisting of two castings, held by bolts and steel hoops, as shown.

The main columns B B are hollow; they have annular projections or rings C C cast at each end, which fit into corresponding recesses, cast in the top and bottom frame pieces.

The large press cylinder D is fitted and held in the top frame; the anvil block rests in the bottom frame. Weldless steel hoops are shrunk on to the cylinder to give additional strength, as clearly shown in section. E is the main ram. It has a strong shank to it, which passes through the top of the cylinder, acting as a guide. F is a steam cylinder with pist.n, the piston-rod of which passes through the gland at the bottom of the cylinder, and is attached to the shank of the ram. G is a crosshead working in guides, thus preventing the ram from turning round.

The force pumps may be appropriately termed "duplex," the ends or faces of the two plungers H H advancing and receding to and from each other simultaneously at each stroke. They work into opposite ends of the pump cylinder I. This cylinder has no bottom, and becomes simply a strong tube. The two plungers are worked by a three-throw crank J, the two side throws of which are on exactly opposite centers to the middle throw. The two side throws give motion to the plunger furthest from the crank, in which case the strain exerted is a pull; while the middle throw gives motion to the plunger nearest to the crank, and the strain is a thrust or push. By this arrangement it will be observed that an absolute balance of force is obtained, and all strains between the crank and pump are avoided.

As before observed, a free communication is at all times maintained between the pump cylinder and the press cylinder. This is done through the pipe K, and when all are full of water and the engine working, an ascending and descending motion is imparted to the press ram at each revolution of the crank, the descending motion being given by the press plungers H H advancing toward each other and forcing the contents of the pump cylinder into the press cylinder, the ascending motion taking place by means of the steam piston, which, on the return stroke, raises the ram, and forces the water back on to the pump plungers as they recede from each other; so that as long as there is no waste of water by leakage, and its quantity is not increased or decreased, the press ram will continue to oscillate at the same distance from the anvil, and could only operate on work of that exact size. The ram has, therefore, to be raised or lowered to suit the various requirements of work in hand, and to effect this a source of supply of water under a pressure of about 250 pounds has to be provided, which, when admitted into the press cylinder, has sufficient force to overcome the power of the steam in the steam cylinder, sending the steam back into the boilers. By this means the ram is rapidly brought down any required distance; on the other hand, the power of the steam immediately raises the ram upon the water being allowed to escape.

The valve used for the rapid admission and escape of water becomes, therefore, rather an important feature, and is shown in Fig. 2. It consists of a cylindrical casing, having a hollow cylindrical valve or plunger, working endwise through hydraulic leathers; at each end of this valve or plunger very fine slits are sawn lengthwise through its sides or walls. The principle of the valve is the allowing of the admission and escape of water through the fine slits, by moving the valve endwise until the fine slits pass the hydraulic leather; the set of slits at one end

* Paper read before the Iron and Steel Institute.—*Engineering.*

of the valve being for the admission of water, and those at the other for the escape.

L is the casing bored through and fitted with hydraulic leathers shown in section. M is the inlet, N the outlet, and O a passage into the pipe K. The valve or plunger is fitted pretty freely into the casing, and is capable of being easily moved endwise. It is hollow, with a solid division in the center, the hollow forming a sort of cup on each side of the solid part, and through the side walls of these cups the fine slits are cut.

When it is desired to bring the press ram down, the valve is moved endwise to the left until the fine slits pass the hydraulic leather, and a passage is thereby opened from the inlet M through the slits, and water is admitted into the passage O, and then onto the pipe K, and the ram at once descends. When it is desired to raise the ram the valve is moved to the right, and water passes out through the other set of slots, and away by the outlet N, and the ram at once ascends by the action of the steam.

It should be observed that at the time the slits pass the leather the low pressure only is in operation, and at the moment of impact of the ram upon the work the valve is always in its neutral position, the position shown in the diagram, the plain body of the central portion of the valve, with a cup leather on each side, being all that is exposed to the great pressure.

The proper time for the admission of additional water is when the pump plungers are receding from each other, and the valve should always be put in its neutral position before the ram face comes upon the work. This arrangement of valve is found to operate most successfully, and the change of position of the ram is effected as quickly as is necessary or desirable. The valve, being in perfect equilibrium, is most easily worked by a handle, brought to a convenient position for the operator to see the work in hand.

The ram may be raised or lowered for its entire range in very few seconds. It can be brought down to the greatest nicety a little lower down each stroke, enabling forgings to be made correct to dimensions, or in case of any sudden occurrence, when it is found undesirable for the impending pressure to take place, the stroke can instantly be averted by moving the valve to the right, although the face may even be in contact with the work. The ram, in fact, is perfectly under control, and almost as lively as the tup of a hammer. An accumulated power is obtained by two heavy fly-wheels on the crank-shaft of the pumps, the momentum of which imparts very great force at the moment of impact of the ram, at which time the cranks approach and turn their centers.

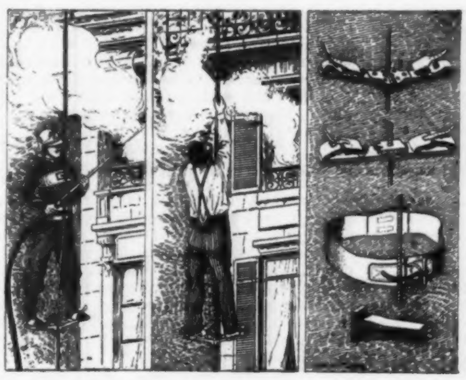
As a security against accident, and a precaution against this force becoming too great, a system of safety valves has been devised (although not shown in the diagrams). It consists simply of a steam cylinder and piston, the piston rod of which works into a small hydraulic cylinder that is in constant connection with the pipe K. Steam is admitted into the steam cylinder at the opposite end to that of the piston rod, and when the hydraulic pressure on the end of the piston-rod becomes sufficient, it forces the steam back into the boilers. Thus, if the steam piston is 60 inches in diameter, and the piston-rod 6 inches in diameter, and the pressure of steam 50 pounds per circular inch, an hydraulic pressure on the end of the piston-rod of 5,000 pounds per circular inch will be an equivalent, and a pressure exceeding that will force the steam back into the boilers, and relief for the water will thereby be obtained.

The press ram makes a stroke of 2⅞ inches, and its diameter is 30 inches, so that at a pressure of three tons per square inch (deducting the area of the shank) we have a power of 1,700 tons. But, of course, no pressure is developed till resistance takes place; hence no power is lost or consumed (except what is lost by friction) until the ram face comes in actual contact with the work, and then sufficient pressure only is developed and consumed to do the work. The press was fitted up by W. and J. Galloway & Sons, of Manchester, and with the exception of the steam cylinder F, it is constructed entirely of steel. The form and strength of all the parts have proved to be capable of sustaining the sudden and great strains to which they are subjected, and no springing or flinching takes place—the ram always descending to the same spot, whether it has to press 3 inches into an ingot, or has nothing to do. This has been found useful in rounding up, for when the ram is once brought down to the right point to give the required diameter, the work has only to be regularly turned round. Of course all has to be dead tight, but there are no joints except cupped leather ones, and very few of those.

ROPE ASCENDING APPARATUS.

THE apparatus herewith represented is destined to render great services to house painters, and also to firemen, whom it will allow to use both arms at once, and it will provide a certain means of escape to persons overtaken by fire in their house.

It consists of two boards connected by a strong hinge provided in the center with an aperture corresponding to two cavities in the boards to allow of the passage



APPARATUS TO PERMIT OF ASCENDING AN ORDINARY ROPE.

of the rope. The extremities of the boards are provided with straps, which are fastened around either the feet or the thighs.

For the fireman, the apparatus is completed by a belt which passes under the armpits and is provided with a ring for the passage of the rope.

After the straps have been securely fixed to the feet, it suffices, when one wishes to climb, to raise one's self by the strength of the wrists, as in the ordinary manner. Upon then causing the weight of the body to bear upon the boards, the rope is firmly grasped between the two jaws of the apparatus and sliding down the rope is entirely prevented. The arms are then stretched upward to their full length, and the same operation is repeated. In order to descend, it suffices to lift one foot slightly, when the rope, being no longer grasped, the apparatus will slide down it. In order to stop, it suffices to bear upon the board again with the foot.

Our engraving shows two modes of using the apparatus; one with a belt, giving a fireman the free use of his two hands, and the other without a belt, the hands serving as guides along the rope.

Fig. 2 represents the apparatus folded. Fig. 3 represents the first arrangement of the apparatus, which is less practical than the one just described, and which has been abandoned by the inventor. Fig. 4 shows the arrangement of the belt.—*Les Inventions Nouvelles.*

MASTER CAR PAINTERS' CONVENTION.

THE Master Car and Locomotive Painters' Association held their 22d annual meeting at the Arlington Hotel, in Washington, D. C., on September 9, 10 and 11.

The following experiences in regard to car painting and cleaning may be found useful to painters everywhere.

CLEANING CARS WITH SOAP.

The first subject discussed was, "Is there a chemically pure soap that can be safely used for the purpose of cleaning the outside varnished surface of the railway passenger coach while in service, stating soap, results and method of cleaning." Wm. O. Quest read a paper, followed by Thos. Bryne. The secretary also read a paper from J. H. Speer, who was unable to be present. In all the papers the free use of soap was condemned as being injurious to the varnish, and other methods of cleaning were advocated. All soaps had a certain amount of alkali in them, and unless used with great care were ruinous in their application. The subject was considered one of the most important on the list, and the members all took more than usual interest in giving their views and the method of cleaning which they followed. Mr. Brown said he knew of a simple material that would clean and not injure, and exhibited a piece of shellacked panel that had been standing in this cleaner for four days, and had not left a mark on it. It is simply kerosene I use. It does not retain any of its greasy properties, it will evaporate of itself, and will not form any gummy substance while in service; it softens the dirt. I have not been using it generally, but am convinced it would be practical where the car is very dirty. I use No. 0 pumice stone with the kerosene, and I have made up my mind it is just the thing we want.

METHODS OF CLEANING.

Mr. Wood feared the crawling of varnish on this surface, but a little turps wiped over it would remedy this trouble. Mr. Winters had a way of cleaning. He uses golden mineral oil, and has done so for several years. One pound of No. 00 pumice stone to one pint of naphtha and add one gallon of the oil; he can put this on and let the car run a week without injury, then wash it off clean for revarnishing; had cars out over a year, and when cleaned in this way it brought back the luster as good as when first turned out.

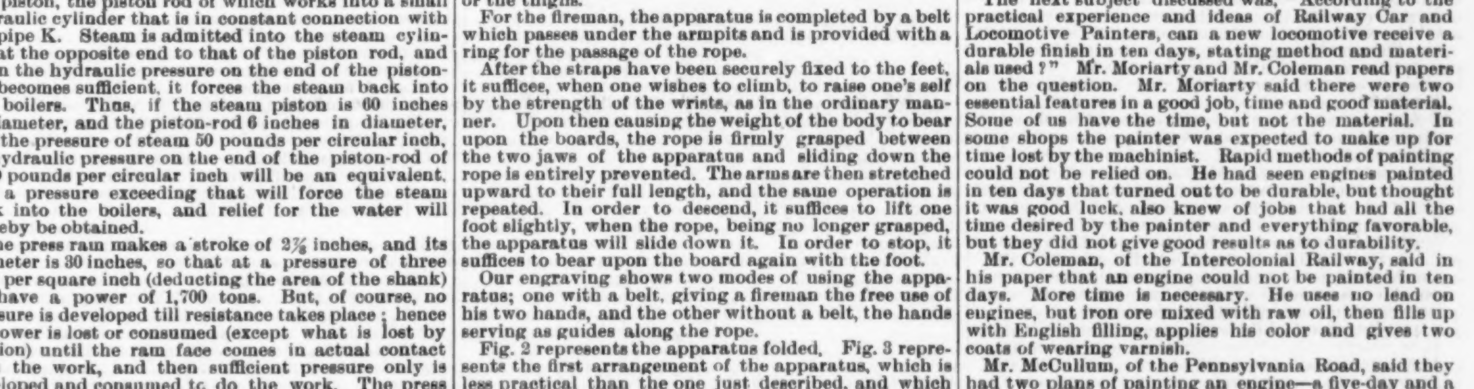
Mr. Bishop said this was not new. He had used it to some extent, but not generally, as he did not know the exact formula; but the next time we meet, you will hear more from me on this question. Two hours were spent in the discussion of the subject and a large amount of information was obt ined from the different methods employed.

CAN A NEW LOCOMOTIVE RECEIVE A DURABLE FINISH?

The next subject discussed was, "According to the practical experience and ideas of Railway Car and Locomotive Painters, can a new locomotive receive a durable finish in ten days, stating method and materials used?" Mr. Moriarty and Mr. Coleman read papers on the question. Mr. Moriarty said there were two essential features in a good job, time and good material. Some of us have the time, but not the material. In some shops the painter was expected to make up for time lost by the machinist. Rapid methods of painting could not be relied on. He had seen engines painted in ten days that turned out to be durable, but thought it was good luck, also knew of jobs that had all the time desired by the painter and everything favorable, but they did not give good results as to durability.

Mr. Coleman, of the Intercolonial Railway, said in his paper that an engine could not be painted in ten days. More time is necessary. He uses no lead on engines, but iron ore mixed with raw oil, then fills up with English filling, applies his color and gives two coats of wearing varnish.

Mr. McCullum, of the Pennsylvania Road, said they had two plans of painting an engine—a five-day and a ten-day. The ten-day was considered durable, the five-day was something else, but they had to get them out



IMPROVED HYDRAULIC FORGING PRESS.

sometimes in that short time. They did not call an engine durable that did not run eighteen months before coming in for repairs and painting.

The president had seen an engine painted in three days and it was durable, but it had simply two coats of metallic oil paint and lettered with oil color.

Mr. Putz, of the Wisconsin Central, stated that on roads that have many tunnels the durability is less; he finished some engines in ten days, but preferred fifteen.

Mr. Mason, of the Pennsylvania Road: We paint engines frequently that don't keep in good condition more than four or five months from some local cause. I don't think that is due to the system of painting. We turn out from fifty to sixty engines a month. I use acid and water to neutralize the rust on a tank where it has accumulated in the yard. We don't consider an engine durable that will not run eighteen months.

A motion was made and passed that it is the sense of this convention that when an engine is painted in ten days and comes in and is cleaned and revarnished, it should give two years' service.

CAR CLEANING.

Mr. Lowry, of the Chicago, Burlington & Northern Road, at La Crosse, Wis., presented an essay on "Car Cleaning," which was read by the secretary. No discussion was allowed on this paper, as it fully agreed with the methods of cleaning which were previously discussed. Oxalic acid was the principal ingredient that Mr. Lowry used, and with satisfactory results.

The next subject on the list was, "As an associate body can we exert an influence on purchasing power that would remedy where necessary the quality of materials furnished?" An item of great importance when viewed from the standpoint that the best procurable is the most economical, as demonstrated by practical experience in the railway paint shop.

James A. Gohen, Robt. McKeon and A. T. Schroeder presented lengthy papers on the subject which went to show the difficulties we labor under by having poor stock and tools in the car paint shop. They advocate a closer acquaintance with the purchasing power, and frequent counsel as the remedy which would insure great benefit to the railway companies.

PAINTING HEAD LINING.

The next subject was, "How should the new wood head lining material of a passenger coach be treated to prevent the finished surface from becoming destroyed from decay of filler grain, raising, etc., due to the interior heat and moisture of a passenger coach?"

Jno. T. McCracken, of the Jackson & Sharp Company, presented a paper, followed by one from Mr. Webb, of the Laconia Car Company, also a paper by Alex. Campbell, of the Manhattan Elevated Road, New York. The methods of the three gentlemen differed only in that some were using terra alba filler and the others corn starch; a general discussion followed. Mr. Putz used corn starch, which he considered equal to terra alba, used by Mr. McCracken, if this is mixed properly. I use in mixing one part raw oil, one part Japan filler and one part gold size, and reduce with turps. Japan gold size is better than the gold size; it dries not so rapidly, but it wears better, no matter what material you use. If it is not well protected with varnish it will not stand atmospheric influences, will draw the material out of the grain of the wood, and I think too much shellac is used on this class of work. I simply give a very thin coat of shellac and two coats of finishing varnish, and our linings stand well indeed.

Mr. Bigelow: We have cars built at Pullman, but the linings soon give out, especially over the lamps and around the stoves, and after two years' service they have to be scraped off and finished over.

The President: I have the pleasure of taking care of linings only as Mr. Brown has, but they don't last, but I think terra alba is a better filler than corn starch; we have cars on our road where the new head linings in them did not run over a year before they had to be scraped, but I lay this to the lack of varnish which was put on when put up.

Mr. Quest: There is an affinity between glue and corn starch. That is where the trouble is. I destroy that by coating the raw lining with oil. I may differ with some of you, but that is the foundation, and I also back up the lining with two coats of metallic paint.

Mr. Stout: I have tried the oil, but I believe one-third oil, one-third turps and one-third gold size will do better.

Mr. Schellar: I used corn starch on linings. I am the father of it, but I became convinced it was not the best.

ROUGH STUFF OUTSIDE OF PASSENGER CARS.

The next question was, As a question of economy and durability, should rough stuff be discarded on the outside of surface of a railway passenger coach? If so, what materials and methods of application will best answer the requirements of this class of work, durability being the main consideration?" Mr. Bishop read a lengthy paper which was in favor of holding on to the rough stuff finish.

Mr. Schellar, of the P., W. & B. road at Wilmington, spoke at length. This is a very important subject, and I think rough stuff should be used, for it is the foundation, and it is not the cause of cracking, as some think, but the varnish is the cause. It is the varnish makers' fault. Lead rough stuff is the best. My method of painting a car is to take boiled oil, heat it to a great heat, and coat the car with the hot oil on the bare wood. Don't spare the oil; put on two gallons on a 60 ft. car. The wood is thoroughly saturated. Oil penetrates deeper when it is hot than cold oil. The next morning it is all absorbed by the wood. Then I put on my priming, mixed with equal parts oil and turps. Mr. Leopold said the hot oil priming would not do in a warm climate. It would keep sweating out with the hot sun and ruin the painted surface. You cannot in our climate use oil, but must use hard drying colors to give good results. Mr. Keil uses rough stuff on panel work, but does not think it practical on beaded work. Mr. Bishop uses rough stuff on all classes of work; it is wood, just the same. Mr. McKeon abandoned rough stuff three years ago, and by the experience is satisfied the work wears equally as well without it. He gives two coats of surface filler, quite thin, then sandpapers it, and he finds the varnish holds out better on this than it does where you use rough stuff and rub with pumice stone, as you will cut the edges more or less in rubbing on panel work. He uses a scraping filler over the priming coat, but not on beaded work. Favors discarding rough stuff, both on the ground of economy and that the paint gives better service. Of course we are not aiming for a fine surface; that is unnecessary on our passenger equipments. No one notices it after it leaves the shop.

After a lengthy discussion a motion prevailed that it was the sense of the meeting that rough stuff should not be discarded on passenger cars. The matter of inspecting the interchangeable test panels, which had been painted and exposed for ten months in different climatic sections of the country, was, for want of time to do justice to them, given into the hands of the secretary, who was required to examine and make a report after the adjournment. The list of queries was fully discussed and valuable information given.

No. 1. Would it be advisable to form a bureau of information in connection with our association? The committee on information, consisting of three members, had attended to this duty, but the number was increased to five, and to be known as a bureau of information.

No. 2. Do you use all or part shellac on the hard wood inside finish of your passenger cars? After a lenghty discussion the majority used shellac for foundation over the filler and finished up with varnish, but Mr. Brown was one who used all shellac with good results. It was brought out during the discussion that there was more durability in shellac than many gave it credit for, but the surface should be oiled over occasionally while in service, which some said was the secret of its durability.

No. 3. How do you prepare your stack blacking for locomotives while in service? Boiled linseed oil and lampblack, made very thin, seemed to be used by many. Put it on when the stack is warm, it wears much better. Some used plumbago and resin reduced with naphtha put on with a piece of waste, and claimed it would outwear the stack. Dixon's graphite was used by the president, and he believed it stood more heat than anything else. Mr. Aquart used drop black thinned with turps; apply with a sponge; they stand well. Mr. Bigelow used boiled oil, lampblack and tallow with fine success. Mr. Brown used drop black, raw oil and varnish (we wondered he did not use shellac), but thinks plumbago is good. Mr. Laing used asphaltum, also Mr. Given. Mr. Moriarty used lampblack and boiled oil. Mr. Mason, raw oil and lampblack; found boiled oil unsatisfactory.

No. 4. What materials do you use, and how long do you take to paint your freight cars? A majority of the members were using Prince's metallic and boiled oil, and the time required to paint a car three days, although in good weather it could be done in two days by second coating and stenciling on the second day.

No. 5. As an item of shop economy in what manner do you keep your paint stock and brushes in the most serviceable state? The discussion on this was general, and most shops had a stockroom with a man in charge who took care of all stock, giving it out only on the order of the foreman or the man in charge of the gang; each man had checks which represented the different class or sizes of brushes, and when a brush was given out a check was left in its place; some shops allowed the coaters, varnishes and stripers their own tools, with a cupboard to keep them in. It was the sense of the meeting that, no matter how small the shop, there should be a stockroom furnished for the proper care of stock and tools.

No. 6. What is the best formula for preparing floor paint for passenger cars? Some did not paint floors, others gave them shellac over the color, which in many shops was a standard paint adopted by the road. Shellac hardens the surface, and will outwear varnish; they all look well when run out, but don't last long.

No. 7. What are your views concerning piecework for the railway paint shop? The general opinion was, it is what all must come to; it was giving the best of satisfaction in all shops where it was tried, and a large number of members were running their shops on that plan. The companies were getting their work done for two-thirds the expense for labor that it cost them under the day and hour system. Some said it would not work in a small shop; others who had adopted it stated they would not change back if they had but two men, and in all cases the workmen were better satisfied and making better wages; so that both employer and employe were greatly benefited by the introduction of the piecework in their shops.

The discussion on the several subjects on the list having closed and the usual resolutions passed, the convention adjourned at a late hour Friday evening, to meet in Detroit, Mich., on the second Wednesday of September, 1892.—*Nat. Car Builder.*

THE NEW YORK SALT INDUSTRY.

THE famous salt region of Onondaga County, in the State of New York, has for over a century been a center for the production of this all-important substance. As long ago as 1770, salt from the salt springs then in existence was used by the Delaware Indians. Eighteen years later the white inhabitants began to make salt by the boiling process, near the site of the present city of Syracuse. The territory from which most of the salt is now produced is a government reservation whose status is established by a treaty made between the Onondaga Indians and the State of New York. The wells are maintained and the brine pumped by the State government, and the brine is delivered to the manufacturers at a royalty of one cent per bushel. The bushel is an arbitrary term indicating a net weight of 56 pounds or one-half hundredweight. The wells, which are sunk and maintained by the State, vary from 150 to 340 feet in depth. Brine is pumped from them which at 60 deg. F. averages 50 deg. to 70 deg. on the salometer. According to Dr. Englehardt's standard table of equivalents, these figures range thus:

Salometer.	Baume.	Per Cent. Salt.	Pounds Salt in Gallon.	Gallons to One Bushel.
50°	13°	13·250	1·206	46·41
70°	18·2°	18·815	1·755	31·89

As a more appreciable standard it may be mentioned that sea water contains 2·7 per cent. of salt, and that it requires 350 gallons to make one bushel of salt.

Originally the tax or royalty was much higher than at present. At one time as much as twelve cents a bushel was charged the manufacturers. Since then it has been reduced, first to six cents, and finally, in 1846, to one cent per bushel. It is evident that at the higher rate a considerable revenue was derived from the wells. For the expense of building the Erie Canal a sum of $2,300,000 was appropriated from the salt royalty. This sum represents nearly one-third of the expense of construction, so that the salt makers are justified in their claim that but for the salt industry the Erie Canal might never have been made.

The salt deposits lie in rocks of the upper Silurian age. The old springs were found in the marshy ground surrounding Onondaga Lake. The waters of the lake are excluded from the salt-bearing strata by impervious marl and marly clay. The wells pass through beds of fine sand and clay. After penetrating these layers a gravel is reached which contains the salt water. The brine is pumped from the gravel beds into reservoirs, whence it is delivered through log piping to the different works.

In Fig. 1 of the illustration is shown a pumping station and reservoir.

The Onondaga brine contains several impurities. The principal is calcic sulphate, more familiar in the form and under the name of gypsum or plaster of Paris. This runs as high as one-half of one per cent. referred to the brines, representing, therefore, two or three per cent. of the dissolved salts. Calcium and magnesium chlorides, with traces of carbonic acid and oxide of iron, are also present. The iron oxide is only objectionable as spoiling the color of the salt, but owing to this its removal is imperative. The calcium and magnesium chlorides are deliquescent. Fortunately they exist in small proportions only in the brines. If in large quantity, they would make the salt moist and give it a tendency to cake, and eventually to become almost liquid. The calcium sulphate is not nearly so soluble as the other salts, and is partly precipitated in the evaporation, and most of it is removed from the concentrated brine. It is obvious that any insoluble matter would be considered an impurity, so that the manufacturer tries to remove this compound as completely as possible.

The salt is obtained by evaporation, either by solar or by artificial heat. In either case the first operation is to clarify the brine by settling. It is allowed to stand in vats in the open air, as shown in Fig. 3, or in factory buildings until the iron oxide has settled and the carbonic acid has escaped or has become precipitated.

At this stage the settling is sometimes aided by the addition of a little milk of lime. Alum or gelatine has been employed or suggested also as a clarifier. Two successive settlings in such vats are applied.

In the next step of the solar process the clarified brine is run into evaporating vats, shown in Fig. 2, where it is acted upon by the sun's heat, and gradually becomes concentrated. Movable covers or roofs are provided to be placed over the vats in case of rain.

As it becomes stronger, the comparatively insoluble calcium sulphate begins to precipitate. The slow evaporation favors crystallization, and the salt begins to separate as large crystals, and is called "coarse salt." As soon as crystals begin to appear, the saturated brine called "salt pickle" is run off into a fourth series of vats for final concentration. As the crystals accumulate in sufficient quantity they are removed and are washed in the fresh pickle. The object of this is to remove the strong brine, which contains a concentration of the calcium and magnesium chlorides. The product is then allowed to drain, and when sufficiently dry is removed to the storehouse. This is an outline of the process of making what is known as "solar salt."

Salt made by artificial heat is known as boiled salt. The term "factory filled" is applied to the purer brands. This term is indicated by the familiar letters F. F. branded on the large sacks. The kettle process, illustrated in Fig. 4, is largely used at the Syracuse works. The brine after settling and clarifying is run into kettles heated by fires underneath. An iron pan with an upright handle is placed in the bottom of each pan.

As the liquid evaporates and the gypsum separates, it accumulates in these pans, and is from time to time removed and thrown aside. This is termed "panning from the kettle." It is here that one essential difference between the solar and boiling process appears. Calcium sulphate or gypsum is less soluble in hot than in cold brine, so that a better separation of this impurity is effected than in the solar process. Each kettle has a capacity of 100 to 120 gallons, and fifty or sixty kettles may be set in a row. As soon as salt crystals begin to appear, the gypsum pan is removed and the salt is taken out by the workmen, is washed with fresh brine and is drained in baskets suspended over the kettles, as shown in the same cut. Brine is run in as required from the central distributing pipe.

The difference in grain in solar and boiled salt is considerable. The solar salt is so coarse that to adapt it for many uses it has to be ground in mills. This is done in the factories, and the product is known as "ground solar" salt. The boiled salt is of a much finer grain, and by the addition of some suitable substance to the kettles the grain may be made still finer. This process is termed "cutting the grain." Salt thus made is called "anthracite salt." The material added consists of traces of such matter as glue, resin, soap, etc. While the process has been known for many generations, it is condemned by many salt makers.

In Fig. 5 of the illustrations we show the modern washing process. The salt is delivered at one end of the apparatus through a chute. The brine enters at the same end and permeates the mass, and as the whole is kept in agitation the washing is very perfect. The salt saturated with the purer brine is drawn off and has to be dried. In the modern process this is done in centrifugal machines, one of which is shown in Fig. 6. There it is whirled around rapidly and the brine is expelled thoroughly by centrifugal force, exactly as sugar is treated for the expulsion of sirup. The separation is, of course, much more complete than where gravity alone is relied on, as in the draining

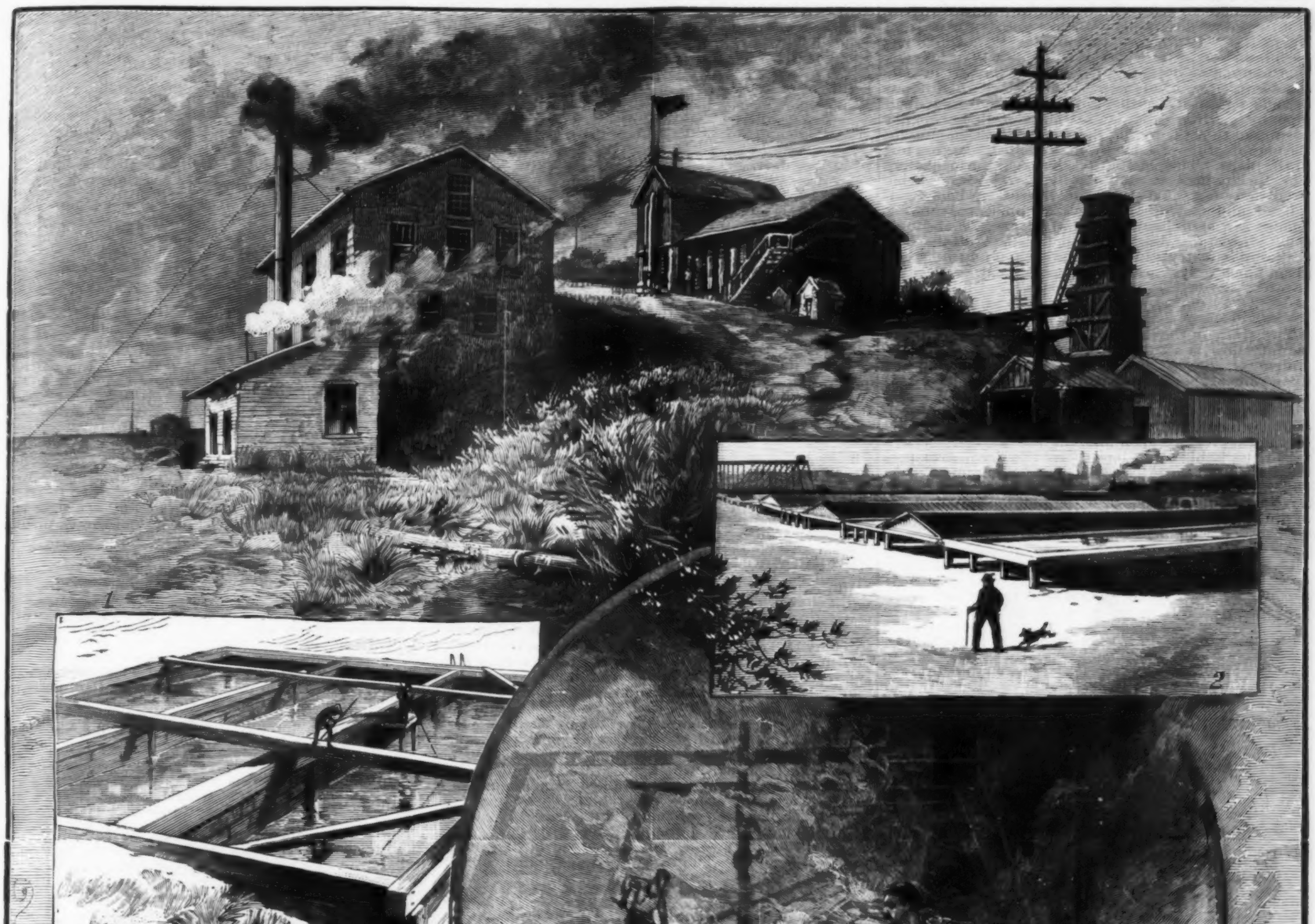
process. When it is remembered that the calcium and magnesium chlorides are mainly present as ingredients of the residual brine, the importance of reducing the amount of this brine as much as possible is evident.

What the future of this historic industry will be is not absolutely certain. The expense of making boiled salt is largely due to the cost of fuel. The kettle process, which we have illustrated, although a relic of the last century, has not yet been superseded. Success has been attained in utilizing anthracite coal dust. Forty to forty-five bushels of salt are produced with the combustion of one ton of anthracite dust, costing $1.75. Some years ago but thirty-seven bushels were produced with the consumption of one ton of bituminous coal costing $4.10. Yet this saving is offset by the fact that the evaporation per pound of fuel is only 5·83 lb. of water—less than half the work of a good steam boiler. One most serious menace comes from the West. Michigan, Ohio, and Kansas are now strong competitors with the New York works. There are two layers of rock salt, forty-five and fifty-four feet thick, seventeen miles south of Syracuse. These may be instrumental in changing the aspect of things in the near future.

The first leases in lots under the auspices of the State took place in 1797. The product for 1798 was 59,928 bushels of solar salt, under the superintendency of William Stevens. In 1889, under Superintendent P. J. Brummelkamp, 2,916,923 bushels of solar and 2,448,138 bushels of boiled salt, making an aggregate of 5,365,061 bushels, were produced. This is not high water mark. The following table gives the years of maximum production and the amounts produced:

Year.	Solar Salt.	Boiled Salt.	Total of both kinds.
1862	1,983,022	7,070,852	9,053,874
1868	2,027,490	6,639,126	8,666,616
1870	2,847,691	6,260,422	9,108,113
1871	2,464,404	5,910,492	8,374,896
1882	3,032,447	5,307,773	8,340,220

Since 1882 the production has constantly decreased.



1 New York State pumping station and reservoir. 2. Solar evaporation. 3. Settling vats. 4. Salt boiling in kettles. 5. Washing salt. 6. Centrifugal drier.

THE SALT INDUSTRY OF ONONDAGA COUNTY, N. Y.

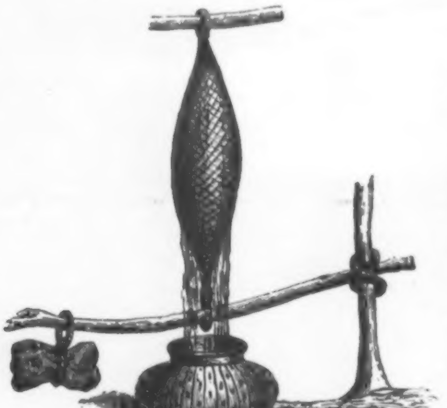
The State exercises a certain supervision over the manufacture. The salt, after making, must be stored at least two weeks before shipment. Before and after the storage period it is inspected by the State inspector. The product as delivered to the public is exceedingly pure. It is gratifying to know that it compares with the finest foreign product in freedom from objectionable magnesium and calcium compounds.

A correspondent of *The Manufacturer* says the salt industry for Syracuse promises to see some great changes soon, from the discovery of salt beds a couple of years ago, about twenty miles south of this city, near the Tully lakes. The lakes are about 800 feet above Syracuse and the twenty-one wells which have been sunk already into the salt beds in that vicinity are about 300 ft. below these lakes and between them and this city. The wells are sunk to a depth of from 974 ft. to 1,465 ft. before striking the salt, which has been found to be from 25 feet to 318 feet in thickness. The method of obtaining it is to flow water from the lakes into the wells by gravity, and then when it has become a saturated brine, it is conveyed by a 12-inch pipe by gravity to Syracuse. Most of this brine has been used thus far by the Solvay Process Company in the manufacture of soda ash, that company having put in the plant. The possibilities, however, of furnishing a practically inexhaustible supply of extra strong brine in this way for the manufacture of salt are being considered and tested, and there is much speculation among salt manufacturers on what may be the outcome of this new discovery and its effect on the now declining industry which has more than anything else given fame to Syracuse.

ANCIENT PRESSES.

THE study of the progress of mankind in the art of manufacture is a subject of great attraction to the student of science; any detail, therefore, which bears upon the art adds one more link to the chain of knowledge.

Referring to the native Indians of the South American continent, and more especially to the inhabitants of the vast regions of Guiana, it has been noted as a very remarkable coincidence that the decorative patterns which frequently ornament the borders of the "Simarri" or grater (a flat slab of wood, surfaced with a resinous gum, embedded with numerous small pieces of flint upon which to grate edible roots) resemble the



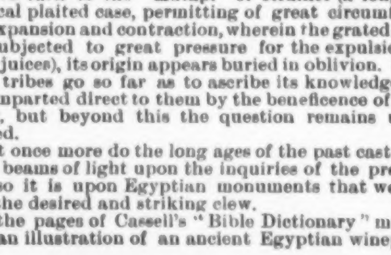
GUIANA ROOT PRESS.

fret patterns of ancient times; the Greek key or Meander device, so common in Egyptian and Assyrian ornamentation and on Etruscan and Greek vases, being of constant occurrence. The coincidence is certainly striking, but a fact still remains with regard to which, so far as known, no attention has been hitherto paid.

If we turn to the "Matapi" or strainer (a long cylindrical plaited case, permitting of great circumferential expansion and contraction, wherein the grated roots are subjected to great pressure for the expulsion of their juices), its origin appears buried in oblivion. Some wild tribes go so far as to ascribe its knowledge as a gift imparted direct to them by the beneficence of their deity, but beyond this the question remains unanswered.

But once more do the long ages of the past cast back their beams of light upon the inquiries of the present, and so it is upon Egyptian monuments that we now find the desired and striking clew.

In the pages of Cassell's "Bible Dictionary" may be seen an illustration of an ancient Egyptian winepress,

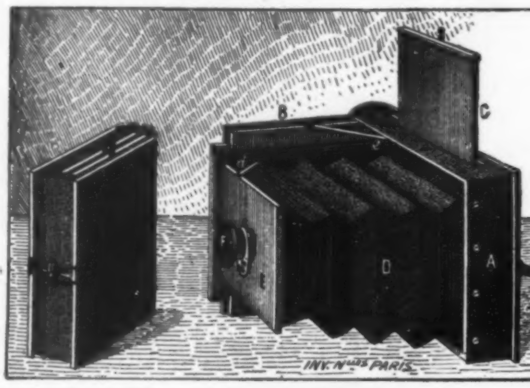


EGYPTIAN GRAPE PRESS.

and clearly we have here the origin of the Matapi of Guiana, and this, coupled with the remarkable use of the Greek, or rather shall we say the Egyptian key device, sets the mind pondering over time and space to discover, if it can, how it is that these modes of earliest decorations and manufacture by old-world African civilization have reached and still retain their hold in darkest regions, and after the lapse of centuries reappear upon modern civilization out from the very depths of the forests in the South American new world.—*George S. Parkinson, in Science-Gossip.*

THE "BOOK" PHOTOGRAPHIC APPARATUS.

As shown in the engraving, the different parts of this apparatus are so combined that they can all be held in a book-shaped box, A, when the instrument is not in use. In order to mount the camera, the cover, B, which forms a carriage and carries a slide that may be advanced more or less for focusing, is opened. The objective carrier, E, which was applied horizontally upon the carriage, B, is raised and brought to an upright position, in which it is held by a bolt and two jointed pieces, *d*. The bellows, D, which is fixed on the one hand in the bottom of the box, A, and on the other against E, is drawn out. It now only remains to push down the books, *c*, which assume the rectangular position of the carriage upon the box, and the apparatus is ready to operate. In order to fold the apparatus up, the operation is just the reverse.—*Les Inventions Nouvelles.*



THE "BOOK" PHOTOGRAPHIC APPARATUS.

ORTHOCHROMATIC COLLODION EMULSION.

DR. A. JONAS has just published one of the most striking and important papers relating to orthochromatic work which has appeared for many years. For some time a special color-sensitive collodion, manufactured by Dr. E. Albert of Munich, has held the front rank for the reproduction of colored objects, paintings, etc. Its chief characteristics are extraordinarily high general and color sensitiveness, and the fact that no yellow screen is necessary for use with the same, the emulsion being so little sensitive comparatively to blue. Dr. Jonas has now published a process which has the same characteristics, and the following is the method of making the emulsion, which might well be undertaken by chemists, and could be supplied to amateurs and professionals, and also to those houses who make a specialty of copying pictures. In Germany it is sold at 12s. the half liter, or 22s. per liter, with the special dye solutions, 1s. per 100 c. c. extra, and the developer at 2s. 6d. per liter. The raw or plain collodion is made as follows:

Solution 1.

Ammonium bromide	64 grammes.
Distilled water	80 c. c.
Absolute alcohol	800 c. c.
Thick collodion, 4 per cent.	1,500 c. c.
Acetic acid	65 c. c.

Dissolve the bromide in the water by the aid of heat; then add the alcohol, collodion, and acetic acid, and shake well.

Solution 2.

Silver nitrate, crystal	80 grammes.
Distilled water	50 c. c.

Dissolve by heat, and add, drop by drop, liquid ammonia 0·91, till the brown precipitate first formed is again redissolved (about 72-75 c. c. are required). Then add 800 c. c. of absolute alcohol, heated to 45° C.

Now, in the dark room, add solution 2 to solution 1 very gradually, shaking between each addition; keep solution 2 at a temperature of 40-50° C. during the mixing, by placing the bottle in hot water. With the above quantity the mixing should take from ten to fifteen minutes. When mixed, a drop of the emulsion is placed on a glass plate, a drop or two of water added, and tested by litmus paper. It should give an acid reaction, and, if alkaline, more acetic acid added to the emulsion, which should be well shaken for fifteen minutes, allowed to stand for an hour, and then poured in a thin stream into five or six times the volume of water. The bromide of silver collodion is, of course, precipitated, and should be collected on a clean linen cloth, the ends of which are tied together so as to form a bag, and this placed in running water for one or two hours to wash. The emulsion is then pressed gently to remove the excess of water, placed on a thick pad of pure filter paper to dry, which takes one or two days. When absolutely dry, which may be known by breaking one or two of the larger pieces of emulsion up, it may be preserved indefinitely in a bottle in an absolutely dark place or may be used to form the raw collodion as follows:

Dry bromide silver collodion	6 grammes.
Absolute alcohol	40 c. c.
Ether	63 c. c.

Dissolve by frequent shaking.

To make this collodion color sensitive, dye solutions are added just before using. The solutions are made as follows:

Eosin Silver Solution.

1. Eosin Solution.

Eosin, crystal	4 grammes.
Distilled water	50 c. c.
Alcohol, 96 per cent.	450 c. c.

2. Silver Solution.

Silver nitrate	3·4 grammes.
Distilled water	50 c. c.

Dissolve and add solution of ammonia till the precipitate first formed is redissolved, and add:

Alcohol, 96 per cent., to make... 200 c. c.

3. Ammonium Picrate Solution.

Picric acid	3 grammes.
Distilled water	10 grammes.
Ammonia solution, q. s. to exactly neutralize alcohol, 96 per cent., to	300 c. c.

For use one mixes:

Solution 1	75 c. c.
" 2	30 "
" 3	30 "
Pure glycerine	20 "
Alcohol, 96 per cent.	45 "

This eosin silver solution should be allowed to settle for one or two days, then filtered, and 20 c. c. of the same should be mixed with 100 c. c. of raw emulsion.

Erythrosin Silver Solution.

1. Erythrosin Solution.

Erythrosin, pure	4 grammes.
Distilled water	50 c. c.
Alcohol, 96 per cent	450 c. c.

Dissolve.

The above mentioned solutions of silver and picrate of ammonia are also used for making the following stock solution:

Solution 1	75 c. c.
" 2	30 "
" 3	30 "
Pure glycerine	25 "
Alcohol, 96 per cent	120 "
Distilled water	20 "

The cloudy solution thus obtained is allowed to stand for a quarter of an hour, and then liq. ammonia added drop by drop till it becomes quite clear; the solution is then kept in a corked bottle for one or two days to settle, then filtered, and 20 c. c. added to every 100 c. c. of emulsion immediately before use.

Eosin and erythrosin sensitize bromide of silver for yellow and yellowish green, the maximum effect being visible at D½ E, or midway between the yellow and green. Eosin gives soft harmonious negatives, erythrosin somewhat harder or more contrasted negatives. To sensitive for red and orange it is necessary to use cyanin, preferably the chloro-cyanin, as follows: 0·3 gramme of chloro-cyanin should be dissolved in 50 c. c. of water, and 10 c. c. of this solution added to 100 c. c. of raw emulsion and 1 c. c. of pure glycerine. The cyanin emulsion should then be mixed with an equal quantity of erythrosin emulsion, and one thus obtains a sensitiveness ranging from A in the red to H in the violet.

The dyed emulsions will not keep more than two days, and should be twice filtered through a clean pad of cotton wool before coating the plates.

Eosin silver emulsion, with 51 mg. of free silver nitrate added to every 100 c. c. of emulsion, showed 21 degrees Warnerke, without excess of silver 17° W., erythrosin silver giving respectively 21° W. and 15° W.; the cyanin erythrosin silver emulsion giving 13° W.; therefore the sensitiveness of these plates is equal to that of the ordinary and rapid gelatine dry plate.

The eosin and erythrosin silver solutions are sensitive to light, and must therefore be made and kept in the dark.

As with all collodion emulsions, the plates should receive a substratum, preferably of gelatine solution 1 per cent. with 1½ per cent. of acetic acid, and 2 per cent. of alcohol. The plates are coated exactly in the same way as with the old wet plate collodion, and, as soon as the collodion has set, the plate is exposed, but it will keep damp for thirty or forty minutes without any fear of ill results. After exposure the plate is well washed under a stream of running water until the greasy marks no longer show, then propped up for a minute to drain, and then flooded with the developer, which is made up as follows:

Stock Solution A.

Distilled water	500 grammes.
Sodium sulphite	200 "
Carbonate of potash, from the tartrate	200 "

Stock Solution B.

Hydroquinone	25 grammes.
Alcohol, 96 per cent	100 c. c.

Stock Solution C.

Ammonium bromide	25 grammes.
Distilled water	100 c. c.

The concentrated developer is made up of

Solution A	100 c. c.
" B	5 "
" C	7 "

The actual developer of

Concentrated developer	150 c. c.
Distilled water	1,000 "

The character of the negative may, of course, be altered by increasing or decreasing the quantity of concentrated developer or the proportions of the several ingredients—the hydroquinone giving density, the bromide clearness, and the potash accelerating.

When the image has sufficiently developed, it can either be intensified with the usual acid pyrogallol and silver intensifier, after washing, or it may be fixed in hypo, washed, and then intensified with the above intensifier or the mercury and sulphite, as used for gelatine plates.

A ONE-SOLUTION REDUCER.

The following formula for a good all-around reducer of density is given by Herr Belitski, of Nordhausen:

Potassio-ferric oxalate	15 parts.
Neutral sodium sulphite	15 "
Distilled water	300 "

The solution is of a blood red color, due to the ferric sulphite formed.

Add—

Oxalic acid, crystals	5 parts

and shake till the solution becomes green; then decant from the undissolved acid, and add—

Hyposulphite of soda, crystal	75 parts.

Shake till dissolved, and filter. Keep in well closed bottles, protected from light.

The negative which it is desired to reduce should be well rinsed when it comes from the fixing bath, and laid in the reducer; when the action has proceeded far enough, wash quickly and dry. The solution may be used over and over again till it becomes yellow, when its reducing powers are exhausted.—*Chemist and Druggist.*

[NEW YORK SUN.]

THE FIRST TELEGRAPH MESSAGE.

To the Editor of the New York Sun:

SIR: In justice to the memory of my father, Alfred Vail, and the prominent part he took in the invention and introduction to public use of the electric telegraph, I desire to correct several errors that crept into an article published in *The Sun* of Sunday last, October 11.

As the inventor of all the mechanism of the telegraph and the alphabet, so-called the Morse alphabet, Alfred Vail—not Albert Vail, as the article has it—is certainly entitled to be called something more than "a friend who had been sent to Annapolis, and who would try to send a message." As a matter of fact, Alfred Vail was in full charge of the electrical features of the construction of the line between Washington and Baltimore, built by the $30,000 appropriated by Congress.

Allow me also to correct the statement that "among the earliest messages while the line was in its experimental state was one from Baltimore on May 1, 1844, announcing the nomination of Henry Clay to the presidency by the Whig convention." As the telegraph line at that date did not extend beyond Annapolis Junction, some twenty miles from Baltimore, the message could not have been sent from the latter city—by telegraph, at least.

The story of that message is as follows: On May 1 Prof. Morse, at Washington, wrote to Mr. Vail, who was at Annapolis Junction, as learned from Mr. Vail's correspondence of the period: "Get from passengers in the cars all the news you can and transmit. A good way of exciting wonder will be to tell the passengers to give you some short sentences to send me, and let them note the time, and call at the capitol to verify the time I received it. Before transmitting notify me (48). Your message to-day that the passengers in the cars gave three cheers for Henry Clay excited the highest wonder in the passenger who gave it to you to send when he found it verified at the capitol."

In response to the request of Prof. Morse that he obtain information from the passengers in the cars, Mr. Vail obtained on the afternoon of that day, May 1, from them, as the train from Baltimore stopped on its way to Washington, the information that the convention had assembled that morning, and that Henry Clay had been nominated for president and Frelinghuysen for the vice-presidency.

Morse, at the capitol in Washington, awaited the signal (48) from Mr. Vail that he had news to transmit him, surrounded by a throng of the curious, who had been informed that great things might be expected to be shown by the telegraph, upon this the first occasion of the transmission of intelligence of a public character. Suddenly the signal from Mr. Vail was heard, and Morse, all excitement and eagerness, bent forward to decipher the characters that appeared embossed upon the little strip of paper as it crept from the register.

The message at last completed, he rose and said: "Gentlemen, the convention has adjourned. The train from Baltimore, bearing that information, has just left Annapolis Junction, and Mr. Vail has telegraphed me the ticket nominated, and it is"—and he hesitated, holding in his hand the proof of the victory of science over space—"it is Clay and Frelinghuysen!"

The train bearing the delegates took one hour and a quarter to reach Washington from Annapolis Junction, and long before it reached the station in Washington, the newspapers had "extras" upon the streets, and the consternation of the delegates as they emerged from the train, each one anxious to be foremost in sending abroad the inspiriting news that fortune was with "Harry of the West," can be better imagined than described as they saw the great crowd surround ing the station and heard their cheers for the nominees, for they, in common with all, had no belief in the telegraph, and had joked about it as they passed the wires strung along the railroad they had just passed over.

On May 2, 1844, Mr. Vail wrote in a private letter: "I yesterday announced the nomination of Henry Clay and Frelinghuysen at Washington, one hour and a quarter before the cars arrived there, distance twenty-two miles. So far the telegraph succeeds perfectly, and perhaps in two weeks we shall be in Baltimore. The telegraph produces a great deal of excitement, and we are thronged with visitors. When we get to Baltimore it will be still more astonishing."

On May 11, 1844, Prof. Morse wrote to Mr. Vail: "Everything worked well yesterday. I shall have a great crowd to-day, and wish all things to go off well. Many M. C.'s will be present, perhaps Mr. Clay. Give me news by the cars. When the cars come along try and get a newspaper from Philadelphia or New York, and give items of intelligence. The arrival of the cars at the junction begins to excite the greatest interest here, and both morning and evening I have my room here at the capitol thronged."

As a strictly historical fact the real "first message" ever transmitted by telegraph—that is, by the only telegraph that has ever had practical success, which is the so-called "Morse telegraph," and transmitted by the characters now in universal use, the so-called Morse alphabet—was that sent over three miles of bonnet wire stretched around the walls of a large room on the second floor of the now historic "Factory," at Speedwell Iron Works, Morristown, N. J., on January 6, 1838.

The story of that message is graphically described by Mr. William Baxter, embodied in an article published in the *Century Magazine* in April, 1888. Morse, while professor of art at the University of the City of New York, had so deeply interested Alfred Vail, a student, in his experiments in the production of a system of transmission of intelligence by electricity that a partnership was formed, resulting in both Morse and Vail leaving the university and going to Morristown to continue their work at the iron works at Speedwell, one mile from the town, belonging to Judge Stephen Vail, the father of Alfred, who had promised to give Morse a home and furnish the money necessary to conduct experiments, and if possible insure success.

William Baxter, who makes this recital, was at the time referred to an apprentice at the Speedwell Iron Works, and was selected to assist Alfred Vail in his improvements upon the original and then proved valueless mechanism devised by Morse, and they were engaged night and day in pushing forward to completion the construction of the new machinery. Mr. Baxter, writing of this period, says:

Alfred Vail was singularly modest and unassuming, while Prof. Morse was very much inclined to insist upon the superiority of his own plans and methods, if for no other reason than because they were his own. As we all looked upon him with the respect due to a professor, we were at first quite willing to defer submissively to his dicta. It resulted from this that the first machine, which was constructed at Speedwell, was substantially a copy of the original model, although constructed of metal, and in a more symmetrical and practical form.

As we became acquainted with Morse, it became evident to us that his mechanical knowledge and skill were limited, and his ideas, in matters relating to construction, of little value. As the weak points in his (Morse's) apparatus were one after another developed, Mr. Vail began to draw upon the resources of his own wonderful power of invention in substituting practical and commercially valuable mechanical combinations for the more or less impracticable designs of Morse.

We found, for example, that the pencil of the recording apparatus frequently required repointing, and that when freshly sharpened it made a different mark from that made by a worn point, which tended to render the record obscure and difficult to decipher. Mr. Vail contrived a fountain pen that made a uniform line. This device, however, was not satisfactory to him, as it threw the ink in all directions when jerked by the sudden action of the magnet, and he spent some time in diligent study in the endeavor to devise a remedy.

He was a mechanical draughtsman of surpassing skill, as is fully attested by some of his work still in possession of his family. He brought to me one day, after working for an hour at his drawing table, a sketch of a new working device in which a vertical motion was given to the lever, instead of the transverse movement which had hitherto been employed. We constructed the new lever, and thus for the first time produced a register capable of making dots, dashes, and spaces.

Mr. Vail's brain was at this time working at high pressure, and evolving new ideas every day. He saw in these new characters the elements of an alphabetical code by which language could be telegraphically transmitted in actual words and sentences, and he instantly set himself at work to construct such a code. His general plan was to employ the simplest and shortest combinations to represent the most frequently recurring letters of the English alphabet, and the remainder for the more infrequent ones. For instance, he found, upon investigation, that the letter *e* occurs much more frequently than any other letter, and accordingly he assigned to it the shortest possible symbol, a single dot (.) On the other hand, *j*, which occurs infrequently, is expressed by dash-dot-dash-dot (—.—.) After going through a computation in order to ascertain the relative frequency of the occurrence of different letters in the English alphabet, Mr. Vail was seized with a sudden inspiration, and visited the office of the Morristown local newspaper, where he found the whole problem worked out for him in the type cases of the compositors.

In this statement I have given the true origin of the misnamed "Morse alphabet," the very foundation and corner stone of a new system, which has since become the universal telegraphic language of the world.

On Jan. 6, 1838, the new instruments were set up in the vacant room in the old factory at Speedwell, and on the 10th and 11th of the same month there was a public exhibition to the people of Morristown, in operation through three miles of wire, at which was present the then proprietor of *The Sun*, Mr. Moses S. Beach, a warm friend of Judge Vail, the father of Alfred.

Writing of this progress in the work, Mr. Baxter continues:

The path to this land of promise was not by any means strewn with roses. It could hardly have been expected that Judge Vail, who was the actual financial supporter of the enterprise, would go on for months making a constant outlay without seeing any result. It was too large a sum of money to be to all appearances thrown away on an invention, the practical use of which was little understood or appreciated, and the ultimate success of which was, to say the least, problematical. The superior wisdom of his neighbors and the sarcastic remarks of the villagers irritated and discouraged him, so that by degrees he grew morose and ill-tempered, and at length utterly refused to look at the machinery or to assist in its construction, thus leaving us to find our own way out of the accumulating difficulties as we could.

It was a trying ordeal, for we were convinced that if a favorable result were not reached at an early day, the judge would order the experiments discontinued. During the last days of 1837 the crisis seemed so close at hand that Morse and Mr. Alfred carefully avoided meeting the judge for fear of precipitating the denouement. We confined ourselves closely to the room and worked assiduously at the apparently endless task, determined, if possible, to accomplish it before our opportunity for doing so was withdrawn. Each succeeding day, at noon, I was directed to watch and report when the judge left the works to go to his dinner, whereupon Morse and Mr. Alfred would steal out and dine at the house of Dr. Cutler, a brother-in-law of Mr. Alfred, who lived near by, and hurry back to the room before the judge returned.

It was a time of extreme anxiety for us, as well as a critical point in the history of the telegraph. We well knew that unless a satisfactory result were soon reached the work must stop, never to be resumed by us, and we felt that at any moment the fate of a great invention might be decided for all time. But time and patience conquer all, and at length we had the unutterable satisfaction of knowing that the machine was at last in working condition. I recall vividly, even after the lapse of so many years, the proud moment when Mr. Alfred said to me: "William, go up to the house and invite father to come down and see the machine work."

I did not stop to put on my coat, although it was the 6th of January, but ran in my shop clothes as fast as I possibly could. It was just after dinner when I knocked at the door of the house and was ushered into the sitting room. The judge sat before the broad fireplace leaning his head on his cane, apparently absorbed in deep meditation. As I entered the room he looked up and said, "Well, William?" and I answered, "Mr. Alfred and Mr. Morse sent me to invite you to come down to the room to see the telegraph machine work." He started up as if the importance of the message impressed him deeply, and in a few minutes we were standing in the experimental room. After a short explanation he called for a piece of paper, and writing upon it these words, "A patient waiter is no loser," he handed it to Mr. Alfred, saying, "If you can send this, and Mr Morse can read it at the other end, I shall be convinced."

He knew that Morse could not possibly be cognizant of the contents of the message, and hence that there could be no collusion between the experimenters, and in any event he had perfect faith in both; so that, when the message was translated from the machine by Morse and handed to him, the duplicate in every word of his own dispatch, he knew that the invention was a demonstrated success, and he then, perhaps for the first time, fully realized its actual importance.

The unexpected result of the experiment overcame his usual equanimity and he gave way in an instant, apparently wholly overcome by his emotions. He had scarcely seen or spoken to his son Alfred for six weeks, and the meeting, under such auspicious circumstances, was a most joyous one. In the exuberance of his happiness the judge proposed to go at once to Washington and urge upon Congress the establishment of a government telegraph. He was perhaps the most influential adherent in his part of the country of the Van Buren administration, then in power, and hence apprehended but little difficulty in effecting the desired result. But it afterward was proved that the assistance of Congress was not so easily to be procured.

It was not until after five long and weary years of effort by those interested in the invention that on the last night of the session and the last hour of the night, March 3, 1844, the bill appropriating the $30,000 before referred to was passed by the Senate and signed by the President.

This, then, is the story of the veritable "first message" that was ever sent, in the characters of the now universal dash-and-dot alphabet, over a wire by the use of electricity, and, although the slip of paper upon which it was written by Judge Vail and that other strip upon which it appeared in the cabalistic characters devised by Alfred Vail are not known to be in existence, the message, "A patient waiter is no loser," should be recognized and accepted as the first message by telegraph.

STEPHEN VAIL.

New York, Oct. 13.

THE MOLECULAR PROCESS IN MAGNETIC INDUCTION.*

By Prof. J. A. EWING.

MAGNETIC induction is the name given by Faraday to the act of becoming magnetized, which certain substances perform when they are placed in a magnetic field. A magnetic field is the region near a magnet, or near a conductor conveying an electric current. Throughout such a region there is what is called magnetic force, and when certain substances are placed in the magnetic field, the magnetic force causes them to become magnetized by magnetic induction. An effective way of producing a magnetic field is to wind a conducting wire into a coil and pass a current through the wire. Within the coil we have a region of comparatively strong magnetic force, and when a piece of iron is placed there, it may be strongly magnetized. Not all substances possess this property. Put a piece of wood or stone or copper or silver into the field, and nothing noteworthy happens; but put a piece of iron or nickel or cobalt, and at once you find that the piece has become a magnet. These three metals, with some of their alloys and compounds, stand out from all other substances in this respect. Not only are they capable of magnetic induction—of becoming magnets

* Abstract of Friday Evening Discourses delivered at the Royal Institution, on May 22, 1891, by J. A. Ewing, M.A., F.R.S., Professor of Applied Mechanics and Mechanism in the University of Cambridge.—*Nature.*

while exposed to the action of the magnetic field—but when withdrawn from the field they are found to retain a part of the magnetism they acquired. They all show this property of retentiveness, more or less. In some of them this residual magnetism is feebly held, and may be shaken out or otherwise removed without difficulty. In others, notably in some steels, it is very persistent, and the fact is taken advantage of in the manufacture of permanent magnets, which are simply bars of steel, of proper quality, which have been subjected to the action of a strong magnetic field. Of all substances, soft iron is the most susceptible to the action of the field. It can also, under favorable conditions, retain, when taken out of the field, a very large fraction of the magnetism that has been induced—more than nine-tenths—more, indeed, than is retained by steel; but its hold of this residual magnetism is not firm, and for that reason it will not serve as material for permanent magnets. My purpose to-night is to give some account of the molecular process through which we may conceive magnetic induction to take place, and of the structure which makes residual magnetism possible.

When a piece of iron or nickel or cobalt is magnetized by induction, the magnetic state permeates the whole piece. It is not a superficial change of state. Break the piece into as many fragments as you please, and you will find that every one of these is a magnet. In seeking an explanation of magnetic quality we must penetrate the innermost framework of the substance—we must go to the molecules.

Now, in a molecular theory of magnetism there are two possible beginnings. We might suppose, with Poisson, that each molecule becomes magnetized when the field begins to act. Or we may adopt the theory of Weber, which says that the molecules of iron are always magnets, and that what the field does is to turn them so that they face more or less one way. According to this view, a virgin piece of iron shows no magnetic polarity, not because its molecules are not magnets, but because they lie so higgledy-piggledy as regards direction that no greater number point one way than another. But when the magnetic force of the field begins to act, the molecules turn in response to it, and so a preponderating number come to face in the direction in which the magnetic force is applied, the result of which is that the piece as a whole shows magnetic polarity. All the facts go to confirm Weber's view. One fact in particular I may mention at once—it is almost conclusive in itself. When the molecular magnets are all turned to face one way, the piece has clearly received as much magnetization as it is capable of. Accordingly, if Weber's theory be true, we must expect to find that in a very strong magnetic field a piece of iron or other magnetizable metal becomes *saturated*, so that it cannot take up any more magnetism, however much the field be strengthened. This is just what happens; experiments were published a few years ago which put the fact of saturation beyond a doubt, and gave values of the limit to which the intensity of magnetization may be forced.

When a piece of iron is put in a magnetic field, we do not find that it becomes saturated unless the field is exceedingly strong. A weak field induces but little magnetism; and if the field be strengthened, more and more magnetism is acquired. This shows that the molecules do not turn with perfect readiness in response to the deflecting magnetic force of the field. Their turning is in some way resisted, and this resistance is overcome as the field is strengthened, so that the magnetism of the piece increases step by step. What is the directing force which prevents the molecules from at once yielding to the deflecting influence of the field, and to what is that force due? And again, how comes it that after they have been deflected they return partially, but by no means wholly, to their original places when the field ceases to act?

I think these questions receive a complete and satisfactory answer when we take account of the forces which the molecules necessarily exert on one another in consequence of the fact that they are magnets. We shall study the matter by examining the behavior of groups of little magnets, pivoted like compass needles, so that each is free to turn except for the constraint which each one suffers on account of the presence of its neighbors.

But first let us see more particularly what happens when a piece of iron or steel or nickel or cobalt is magnetized by means of a field the strength of which is gradually augmented from nothing. We may make the experiment by placing a piece of iron in a coil and making a current flow in the coil with gradually increased strength, noting at each stage the relation of the induced magnetism to the strength of the field. This relation is observed to be by no means a simple one; it may be represented by a curve (Fig. 1), and an in-

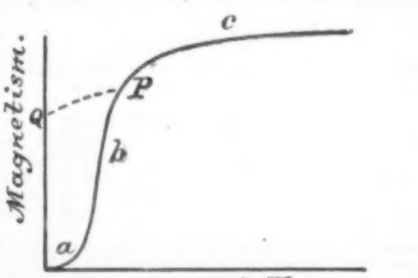


Fig. 1.

spection of the curve will show that the process is divisible, broadly, into three tolerably distinct stages. In the first stage (*a*) the magnetism is being acquired but slowly; the molecules, if we accept Weber's theory, are not responding readily—they are rather hard to turn. In the second stage (*b*) their resistance to turning has to a great extent broken down, and the piece is gaining magnetism fast. In the third stage (*c*) the rate of increment of magnetism falls off: we are there approaching the condition of saturation, though the process is still a good way from being completed.

Further, if we stop at any point of the process, such as P, and gradually reduce the current in the coil until there is no current, and therefore no magnetic field, we shall get a curve like the dotted line PQ, the height of Q showing the amount of the residual magnetism.

If we make this experiment at a point in the first stage (*a*), we shall find, as Lord Rayleigh has shown, little or no residual magnetism; if we make it at any point in the second stage (*b*), we shall find very much residual magnetism; and if we make it at any point in the third stage (*c*), we shall find only a little more residual magnetism than we should have found by making the experiment at the end of stage *b*. That part of the turning of the molecules which goes on in stage *a* contributes nothing to the residual magnetism. That part which goes on in stage *c* contributes little. But that part of the turning which goes on in stage *b* contributes very much.

In some specimens of magnetic metal we find a much sharper separation of the three stages than in others. By applying strain in certain ways it is possible to get the stages very clearly separated. Fig. 2, a beautiful

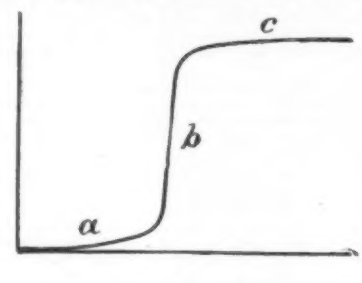


Fig. 2.

instance of that, is taken from a paper by Mr. Nagaoka—one of an able band of Japanese workers who are bidding fair to repay the debt that Japan owes for its learning to the West. It shows how a piece of nickel which is under the joint action of pull and twist becomes magnetized in a growing magnetic field. There the first stage is exceptionally prolonged, and the second stage is extraordinarily abrupt.

The bearing of all this on the molecular theory will be evident when we turn to these models, consisting of an assemblage of little pivoted magnets, which may be taken to represent, no doubt in a very crude way, the molecular structure of a magnetizable metal. I have here some large models, where the pivoted magnets are pieces of sheet steel, some cut into short flat bars, others into diamond shapes with pointed ends, others into shapes resembling mushrooms or umbrellas, and in these the magnetic field is produced by means of a coil of insulated wire wound on a large wooden frame below the magnets. Some of these are arranged with the pivots on a gridiron or lazy-tongs of jointed wooden bars, so that we may readily distort them, and vary the distances of the pivots from one another, to imitate some of the effects of strain in the actual solid. But to display the experiments to a large audience a lantern model will serve best. In this one the magnets are got by taking to pieces numbers of little pocket compasses. The pivots are cemented to a glass plate, through which the light passes in such a way as to project the shadows of the magnets on the screen. The magnetic force is applied by means of two coils, one on either side of the assemblage of magnets and out of the way of the light, which together produce a nearly uniform magnetic field throughout the whole group. You see this when I make manifest the field in a well known fashion, by dropping iron filings on the plate.

We shall first put a single pivoted magnet on the plate. So long as no field acts, it is free to point anyhow—there is no direction it prefers to any other. As soon as I apply even a very weak field it responds, turning at once into the exact direction of the applied force, for there was nothing (beyond a trifling friction at the pivot) to prevent it from turning.

Now try two magnets. I have cut off the current, so that there is at present no field, but you see at once that the pair has, so to speak, a will of its own. I may shake or disturb them as I please, but they insist on taking up a position (Fig. 3) with the north end of one

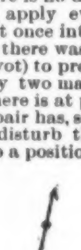


Fig. 3.

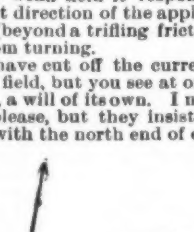


Fig. 4.

as close as possible to the south end of the other. If disturbed they return to it; this configuration is highly stable. Watch what happens when the magnetic field acts with gradually growing strength. At first, so long as the field is weak (Fig. 4), there is but little deflection, but as the deflection increases it is evident that the stability is being lost, the state is getting more and more critical, until (Fig. 5) the tie that holds them together seems to break, and they suddenly turn, with violent swinging, into almost perfect alignment with the magnetic force H. Now I gradually remove the force, and you see that they are slow to return, but a stage comes when they swing back, and a complete removal of the force brings them into the condition with which we began (Fig. 3).

If we were to picture a piece of iron as formed of a vast number of such pairs of molecular magnets, each pair far enough from its neighbors to be practically out of reach of their magnetic influence, we might deduce many of the observed magnetic properties, but not all. In particular, we should not be able to account for so much residual magnetism as is actually found. To get that, the molecules must make new connections when the old ones are broken; their relations are of a kind more complex than the quasi-matrimonial one which the experiment exhibits. Each molecule is a member of a larger community, and has probably many neighbors close enough to affect its conduct.

We get a better idea of what happens by considering four magnets (Fig. 6). At first, in the absence of de-

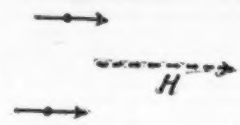


Fig. 5.

Fig. 6.

flecting magnetic force, they group themselves in stable pairs—in one of a number of possible combinations. Then—as in the former case—when magnetic force is applied, they are at first slightly deflected, in a manner that exactly tallies with what I have called the stage *a* of the magnetizing process. Next comes instability. The original ties break up, and the magnets swing violently round; but finding a new possibility of combining (Fig. 7), they take to that. Finally, as

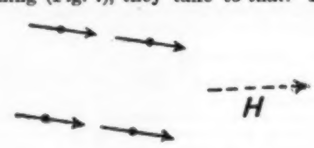


Fig. 7.

the field is further strengthened, they are drawn into perfect alignment with the applied magnetic force (Fig. 8).

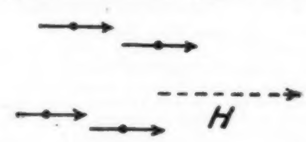


Fig. 8.

We see the same three stages in a multiform group (Figs. 9, 10, 11). At first, the group, if it is shuffled by any casual disturbance, arranges itself at random in lines that give no resultant polarity (Fig. 9). A weak

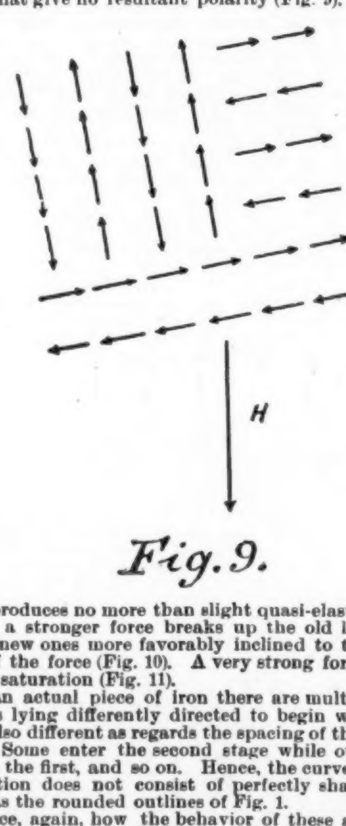


Fig. 9.

force produces no more than slight quasi-elastic deflections; a stronger force breaks up the old lines, and forms new ones more favorably inclined to the direction of the force (Fig. 10). A very strong force brings about saturation (Fig. 11).

In an actual piece of iron there are multitudes of groups lying differently directed to begin with—perhaps also different as regards the spacing of their members. Some enter the second stage while others are still in the first, and so on. Hence, the curve of magnetization does not consist of perfectly sharp steps, but has the rounded outlines of Fig. 1.

Notice, again, how the behavior of these assemblages of elementary magnets agrees with what I have said about residual magnetism. If we stop strengthening the field before the first stage is passed—before any of the magnets have become unstable and have tumbled round into new places—the small deflection simply disappears and there is no residual effect on the configuration of the group. But if we carry the process far enough to have unstable deflections, the effects of these persist when the force is removed, for the magnets then retain the new grouping into which they have fallen (Fig. 10). And again, the quasi-elastic deflections which go on during the third stage do not add to the residual magnetism.

Notice, further, what happens to the group if, after

applying a magnetic force in one direction and removing it, I begin to apply force in the opposite direction. At first there is little reduction of the residual polarity, till a stage is reached when instability begins, and then reversal occurs with a rush. We thus find a close imitation of all the features that are actually observed when iron or any of the other magnetic metals is carried through a cyclic magnetizing process (Fig. 12). The effect of any such process is to form a *loop* in the curve which expresses the relation of the magnetism to the magnetizing force. The changes of magnetism always lag behind the changes of magnetizing force. This tendency to lag behind is called magnetic *hysteresis*.

We have a manifestation of hysteresis whenever a

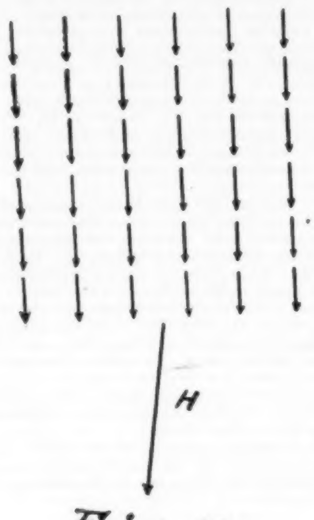


Fig. 10.

magnetic metal has its magnetism changed in any manner through changes in the magnetizing force, unless indeed the changes are so minute as to be confined to what I have called the first stage (a, Fig. 1). Residual magnetism is only a particular case of hysteresis.

Hysteresis comes in, whatever be the character or cause of the magnetic change, provided it involves such deflections on the part of the molecules as make them become unstable. The unstable movements are not reversible with respect to the agent which produces them; that is to say, they are not simply undone step by step as the agent is removed.

We know, on quite independent grounds, that when the magnetism of a piece of iron or steel is reversed, or indeed cyclically altered in any way, some work is spent in performing the operation—energy is being given to the iron at one stage, and is being recovered from it at another; but when the cycle is taken as a whole, there is a net loss, or rather a waste of energy. It may be shown that this waste is proportional to the area of the loop in our diagrams. This energy is dissipated; that is to say, it is scattered and rendered useless: it takes the form of heat. The iron core of a transformer, for instance, which is having its magnetism reversed with every pulsation of the alternating current,

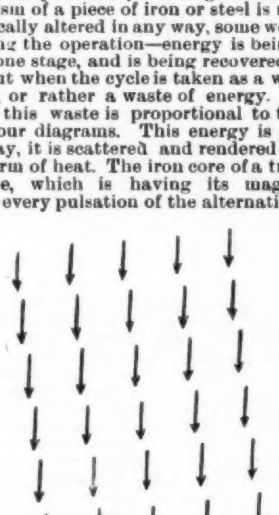


Fig. 11.

tends to become hot for this very reason; indeed, the loss of energy which happens in it, in consequence of magnetic hysteresis, is a serious drawback to the efficiency of alternating current systems of distributing electricity. It is the chief reason why they require much more coal to be burnt, for every unit of electricity sold, than direct current systems require.

The molecular theory shows how this waste of energy occurs. When the molecule becomes unstable and tumbles violently over, it oscillates and sets its neighbors oscillating, until the oscillations are damped out by the eddy currents of electricity which they generate in the surrounding conducting mass. The useful work that can be got from the molecule as it falls over is less than the work that is done in replacing it during the return portion of the cycle. This is a simple mechanical deduction from the fact that the movement has unstable phases.

I cannot attempt, in a single lecture, to do more than glance at several places where the molecular theory seems to throw a flood of light on obscure and complicated facts, as soon as we recognize that the constraint of the molecules is due to their mutual action as magnets.

It has been known since the time of Gilbert that vibration greatly facilitates the process of magnetic induction. Let a piece of iron be briskly tapped while it lies in the magnetic field, and it is found to take up a large addition to its induced magnetism. Indeed, if we examine the successive stages of the process while the iron is kept vibrating by being tapped, we find that the first stage (a) has practically disappeared, and there is a steady and rapid growth of magnetism almost

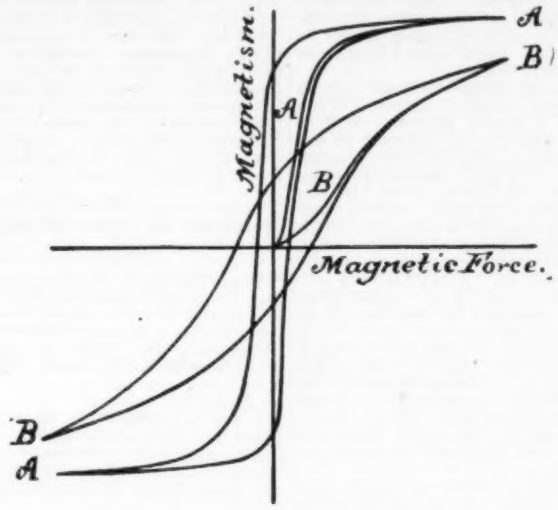


Fig. 12.

FIG. 12.—Cyclic Reversal of Magnetization in Soft Iron, A A, and in the same Iron when Hardened by Stretching, B B.

from the very first. This is intelligible enough. Vibration sets the molecular magnets oscillating, and allows them to break their primitive mutual ties and to respond to weak deflecting forces. For a similar reason, vibration should tend to reduce the residue of magnetism which is left when the magnetizing force is removed, and this, too, agrees with the results of observation.

Perhaps the most effective way to show the influence of vibration is to apply a weak magnetizing force first before tapping. If the force is adjusted so that it nearly but not quite reaches the limit of stage (a), a great number of the molecular magnets are, so to speak, hovering on the verge of instability, and when the piece is tapped they go over like a house of cards, and magnetism is acquired with a rush. Tapping always has some effect of the same kind, even though there has been no special adjustment of the field.

And other things besides vibration will act in a similar way, precipitating the break-up of molecular groups when the ties are already strained. Change of

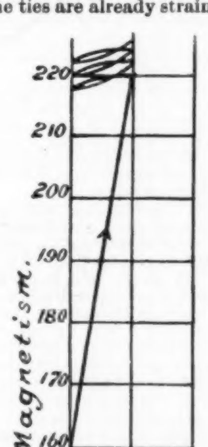


Fig. 13.

Effects of Loading a Soft Iron Wire in a Constant Field.

temperature will sometimes do it, or the application or change of mechanical strain. Suppose, for instance, that we apply pull to an iron wire while it hangs in a weak magnetic field, by making it carry a weight. The first time that we put on the weight, the magnetism of the wire at once increases, often very greatly, in consequence of the action I have just described (Fig. 13). The molecules have been on the verge of turning, and the slight strain caused by the weight is enough to make them go. Remove the weight, and there is only a comparatively small change in the magnetism, for the greater part of the molecular turning that was done when the weight was put on is not undone when it is taken off. Reapply the weight, and you find again but little change, though there are still traces of the kind of action which the first application brought about. That is to say, there are some groups of molecules which, though they were not broken up in the first application of the weight, yield now, because they have lost the support they then obtained from neighbors that have now entered into new combinations. Indeed, this kind of action may often be traced, always diminishing in amount, during several successive applications and removals of the load (see Fig. 13), and it is only when the process of loading has been many times repeated that the magnetic change brought about by loading is just opposite to the magnetic change brought about by unloading.

Whenever, indeed, we are observing the effects of an alteration of physical condition on the magnetism of iron, we have to distinguish between the primitive effect, which is often very great and is not reversible, and the ultimate effect, which is seen only after the molecular structure has become somewhat settled through many repetitions of the process. Experiments on the effects of temperature, of strain, and so forth, have long ago shown this distinction to be exceedingly important: the molecular theory makes it perfectly intelligible.

Further, the theory makes plain another curious result of experiment. When we have loaded and unloaded the iron wire many times over, so that the effect is no longer complicated by the primitive action

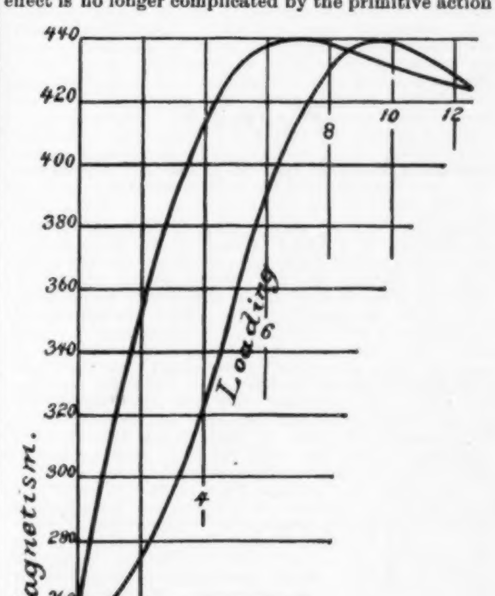


Fig. 14.

Cycle of Loading and Unloading.

I have just described, we still find that the magnetic changes which occur while the load is being put on are not simply undone, step by step, while the load is being taken off. Let the whole load be divided into several parts, and you will see that the magnetism has two different values, in going up and in coming down, for one and the same intermediate value of the load. The changes of magnetism lag behind the changes of load: in other words, there is *hysteresis* in the relation of the magnetism to the load (Fig. 14). This is because some of the molecular groups are every time being broken up during the loading, and re-established during the unloading, and that, as we saw already, involves hysteresis. Consequently to each loading and unloading requires the expenditure of a small quantity of energy, which goes to heat the metal.

Moreover, a remarkably interesting conclusion fol-

lows. This hysteresis, and consequent dissipation of energy, will also happen though there be no magnetization of the piece as a whole: it depends on the fact that the molecules are magnets. Accordingly, we should expect to find, and experiment confirms this (see Phil. Trans, 1885, p. 614), that if the wire is loaded and unloaded, even when no magnetic field acts and there is no magnetism, its physical qualities which are changed by the load will change in a manner involving hysteresis. In particular, the length will be less for the same load during loading than during unloading, so that work may be wasted in every cycle of loads. There can be no such thing as perfect elasticity in a magnetizable metal, unless, indeed, the range of the strain is so very narrow that none of the molecules tumble through unstable states. This may have something to do with the fact, well known to engineers, that numerous repetitions of a straining action, so slight as to be safe enough in itself, have a dangerous effect on the structure of iron or steel.

Another thing on which the theory throws light is the phenomenon of time lag in magnetization. When a piece of iron is put into a steady magnetic field, it does not take instantly all the magnetism that it will take if time be allowed. There is a gradual creeping up of the magnetism, which is most noticeable when the field is weak and when the iron is thick. If you will watch the manner in which a group of little magnets breaks up when a magnetic force is applied to it, you will see that the process is one that takes time. The first molecule to yield is some outlying one which is comparatively unattached—as we may take the surface molecules in the piece of iron to be. It falls over, and then its neighbors, weakened by the loss of its support, follow suit, and gradually the disturbance propagates itself from molecule to molecule throughout the group. In a very thin piece of iron—a fine wire, for instance—there are so many surface molecules, in comparison with the whole number, and consequently so many points which may become origins of disturbance, that the breaking up of the molecular communities is too soon over to allow much of this kind of lagging to be noticed.

Effects of temperature, again, may be interpreted by help of the molecular theory. When iron or nickel or cobalt is heated in a weak magnetic field, its susceptibility to magnetic induction is observed to increase, until a stage is reached, at a rather high temperature, when the magnetic quality vanishes almost suddenly and almost completely. Fig. 15, from one of

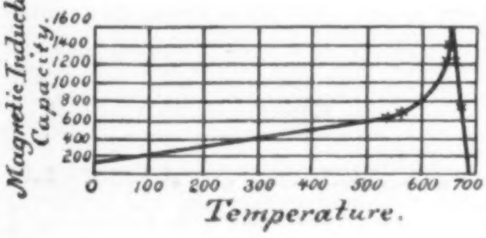


Fig. 15.

Relation of Magnetic Inductive Capacity to Temperature in Hard Steel (Hopkinson).

Hopkinson's papers, shows what is observed as the temperature of a piece of steel is gradually raised. The sudden loss of magnetic quality occurs when the metal has become red hot; the magnetic quality is recovered when it cools again sufficiently to cease to glow. Now, as regards the first effect—the increase of susceptibility with increase of temperature—I think that is a consequence of two independent effects of heating. The structure is expanded, so that the molecular centers lie further apart. But the freedom with which the molecules obey the direction of any applied magnetic force is increased not by that only, but perhaps even more by their being thrown into vibration. When the field is weak, heating consequently assists magnetization, sometimes very greatly, by hastening the passage from stage *a* to stage *b* of the magnetizing process. And it is at least a conjecture worth consideration whether the sudden loss of magnetic quality at a higher temperature is not due to the vibrations becoming so violent as to set the molecules spinning, when, of course, their polarity would be of no avail to produce magnetization. We know, at all events, that when the change from the magnetic to the non-magnetic state occurs, there is a profound molecular change, and heat is absorbed which is given out again when the reverse change takes place. In cooling from a red heat, the iron actually extends at the moment when this change takes place (as was shown by Gore), and so much heat is given out that (as Barrett observed) it reglows, becoming brightly red, though, just before the change, it had cooled so far as to be quite dull. [Experiment, exhibiting retraction and reglow in cooling, shown by means of a long iron wire, heated to redness by the electric current.] The changes which occur in iron and steel about the temperature of redness are very complex, and I refer to this as only one possible direction in which a key to them may be sought. Perhaps the full explanation belongs as much to chemistry as to physics.

An interesting illustration of the use of these models has reached me, only to-day, from New York. In a paper just published in the *Electrical World* (reprinted in the *Electrician* for May 29, 1891), Mr. Arthur Hoopes supports the theory I have laid before you by giving curves which show the connection, experimentally found by him, between the resultant polarity of a group of little pivoted magnets and the strength of the magnetic field, when the field is applied, removed, reversed, and so on. I shall draw these curves on the screen, and rough as they are, in consequence of the limited number of magnets, you see that they succeed remarkably well in reproducing the features which we know the curves for solid iron to possess.

It may, perhaps, be fairly claimed that the models whose behavior we have been considering have a wider application in physics than merely to elucidate magnetic processes. The molecules of bodies may have polarity which is not magnetic at all—polarity, for instance, due to static electrification—under which they group themselves in stable forms, so that energy is dissipated whenever these are broken up and rearranged. When we strain a solid body beyond its limit of elasticity, we expend work irrecoverably in overcoming, as it were, internal friction. What is this internal friction due to but the breaking and making of molecular ties? And if internal friction, why not also the surface friction which causes work to be spent when one body rubs upon another? In a highly suggestive passage of one of his writings,* Clerk Maxwell threw out the hint that many of the irreversible processes of physics are due to the breaking up and reconstruction of molecular groups. The models help us to realize Maxwell's notion, and, in studying them to-night, I think we may claim to have been going a step or two forward where that great leader pointed the way.

THEORY OF THE WIMSHURST MACHINE.†

By M. G. PELLISSIER.

THE Wimshurst machine was invented about 1883, and its use has spread rapidly on account of its possessing the valuable properties of quick self-excitation, certainty of action in all weathers, and entire absence of reversal. Its theory is, however, very little understood, and M. Gariel, in his "Traité d'Electricité," has gone so far as to say that it is not possible to give it in a satisfactory manner.

It can be ascertained by experiment that a Wimshurst machine works perfectly when the combs and discharging rod are drawn back, and the action of the combs can, therefore, be neglected in the theory of the electrical action. If the distribution on the plates of the machine when it is in motion be investigated, it will be found to be as indicated by the signs in the diagram. In order to prove this, Mr. Wimshurst has constructed special apparatus.

One of these instruments, the "sparking machine," is an ordinary one simplified, and consists of two glass plates carrying a large number of tin sectors very close together; these are put in motion with the fingers on a common axle held in the hand; each plate is furnished with a conductor placed along a diameter. As soon as the disks revolve, the sectors become surrounded with halos, sparks fly from point to point, and, when viewed in the dark, a very fine effect is presented. The other instrument only differs from an ordinary machine in having its plates made of an elastic material; when in motion they are seen to attract one another in quadrants I. and III., and to repel in II. and IV.

In the following paper we have sought first to explain how the distribution shown in the diagram can be set up, and then how it is that the charges rapidly increase. In Fig. 1 the front plate is represented by the inner circle; B_1 B_2 are the sectors, of which we will assume there are eight; β β, the diametric conductor. The outer circle represents the back plate, A_1 A_2 its sectors, and α α its diametric conductor. The two wheels turn in opposite directions with the same velocity.

Let us consider one of the sectors, A_1, of the back disk at the instant that it is opposite the diametric conductor, β β, of the other plate; and we will assume that a sector, B_1, of the disk in front is at the same instant in contact with the brush, β.

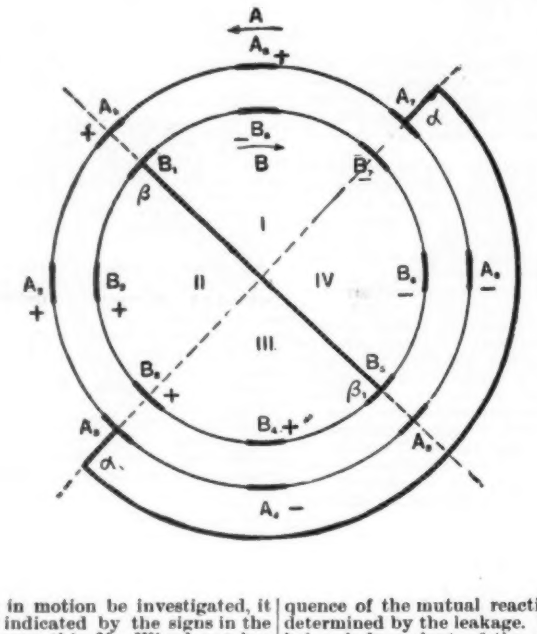
Let us suppose, without inquiring the reason, that the sector, A_1, has a weak positive charge; it will induce on B_1 a negative charge, and then proceed itself toward α_1. When it arrives at this point, that is to say, after revolving through 90 deg., B_1 will, on account of the opposite directions of rotation of the two plates, have arrived opposite the brush, α, which will be in contact with the sector, A_4, while B_3 will be opposite A_1 at α. The charge carried by B_1 will induce on A_4 a positive charge, while A_1, which is positive, will be discharged to earth, since α α_1 is not insulated. After a further rotation through 90 deg., A_4, carrying a positive charge, will take the place of A_1, while B_1 and B_5 will change places. The series of actions just explained will be gone through again, and, since the induced charges are less than the original, the machine would soon cease to work.*

But A_1 does not act only on the sectors of the second plate, but also on the neighboring sectors, A_8 A_2; when they come in contact with the brush, α_1, the positive charge flows to earth and they leave the diametric conductor with a negative charge, which they carry toward the brush, β_1. This brush acts by induction on the sectors of the second plate, which acquire a positive charge and turn from the brush, β_1, in a clockwise direction.

Thus it is sufficient for the sector, A_1, to have at the start a slight positive charge in order to bring about the distribution shown in the diagram. All the sectors of the back plate situated on the left between the brushes, α and α_1, are positively electrified; the opposite sectors on the same plate are negative, while on the front plate all the sectors at the top between β and β_1 are negatively electrified and the opposite sectors at the bottom are positive. In the top quadrant, I., the charges are of opposite sign and attract one another; the same holds good for III., while in II. and IV. the charges are of the same sign and repel one another; and if combs be placed at these points, the one on the right will collect negative electricity, and that on the left positive.

It remains to examine how these charges go on increasing. To do this, let us take the machine in any position whatever, and consider the electrical actions that are taking place on any sector, say B_1, in contact with a brush. This sector is under the influence of (i.) the negative sectors, B_8 B_7 B_6; (ii.) the positive sectors, B_2 B_3 B_4; (iii.) the positive sectors, A_8 A_1 A_2, of the back disk. Since the two first sets are symmetrically disposed, they neutralize one another, and the action of the three sectors, A_8 A_1 A_2, alone remains; each of these tends to give it a charge nearly equal to its own in quantity, but opposite in sign. The sum of these actions will give to B_1 a charge that is approximately three times its original charge.

The same thing holds good for the other sectors, A_8 B_8 B_7, and is renewed for each of the sectors successively. The charges will thus go on increasing in consequence of the mutual reactions up to a point that is determined by the leakage. The action of the machine being independent of the combs, it will continue to work when the knobs of the discharger are separated beyond the sparking distance. This is the explanation of the valuable property that the Wimshurst machine possesses of never failing nor reversing, as is often the case with Holtz and Voss machines.



It is necessary to add to the actions just considered the effects produced on the glass, which are far from being negligible; indeed, the Wimshurst machine can be made of two plates of polished glass, and with combs instead of brushes at the extremities of the diametric conductor. The initial charge has to be given by means of an external source, placed, for example, opposite A_1.†

This form of Wimshurst machine recalls a Holtz of the second kind; the German *savant* had, in fact, made, in 1869, a model of this apparatus, with two diametric conductors in the form of a cross, one before each plate;‡ he even added§ that this machine could be made self-exciting by placing metallic sectors on the plates and substituting brushes for combs on the diametric conductors. It appears that Mr. Wimshurst was unaware of Holtz's work when he invented his machine.

The chief part played by the sectors seems to be to facilitate the self-excitation and to diminish the effect of atmospheric moisture. The greater the number of sectors, the more rapid is the excitation; thus, with eight sectors, or any less number, the machine has to be excited from an external source; with 16 or 18, it rapidly excites itself under almost all atmospheric conditions; while with 40 the action is so energetic that it is very difficult to prevent the machine exciting itself, even under very unfavorable conditions as to moisture.

* "Encyc. Brit." Art. "Constitution of Bodies."

† From *Journal de Physique*.

* This, in fact, is what happens when combs are placed opposite A_3 B_3 and A_6 B_6 and are put to earth. If the theory of the machine under these conditions be examined, it will be seen that the second series of phenomena about to be described do not take place; the charges then diminish in geometrical progression, while the operations increase in arithmetical. It is this which points to the office of the combs in the electrical reactions.

† In the ordinary machine, when the brushes do not touch the sectors, the machine can be made to work by starting it with a charge from an electrified body.

‡ *Pogg. Ann.*, t. cxxxvi., p. 171, 1869; Uppenborn's *Centralblatt. f. Electr.*, p. 683, 1883.

§ *Gotting. Akad.*, March, 1876. Uppenborn's *Zeitschr. f. angew. Elekt.*, t. iii., p. 193, 1881.

At the end of a half turn of the handle, Wimshurst machines are completely excited.

The one point that remains obscure in the theory of influence machines is the origin of the original charge. It has been ascribed to (i.) a residual charge on the plates; (ii.) electrification of the plates by friction with the air; (iii.) electrification of the metallic sectors by the natural electricity of the different layers of air, which are at unequal potentials; (iv.) electrification by contact.

Without denying the existence of these various causes, the last appears the most probable, more especially since the self-excitation is only present in machines furnished with metallic sectors and contact brushes, *e. g.*, Bennet doublers, Topler, Voss, Thomson, and Wimshurst machines. It would be interesting to have exact experiments on this subject.

THE MINERAL RESOURCES OF NEW SOUTH WALES.*

By C. S. WILKINSON, F.G.S., F.L.S.

THE leading industrial position which England occupies among the nations is, we all know, to a great degree attributable to the development of her mineral resources. In this fact we have assurance of the high national destiny which awaits Australia in the not distant future; for not only does Australia possess, to an equal extent, the greatest of England's mineral bases of industry, coal, but our island continent has, in addition, inexhaustible stores of the noble metals, gold and silver, which are of such national importance. Of the world's total production of gold since the year 1851, Australia has contributed about one-third, amounting in value to over £336,000,000, and the value of the silver now annually raised amounts to about £1,715,000. While the production of these alone points to Australia as one of the chief regions for the world's supply of the metals which form the legal money currency of the principal nations, the industrial national prosperity of Australia is foreshadowed in her possession of undeveloped deposits of almost all the known minerals of commercial value. By far the greater number of these occur in New South Wales, and it is remarkable also that, within the boundaries of this colony, nearly all the characteristic physical features of the Australian continent are found represented. It embraces the highest mountains, the largest rivers, the most extensive plains, and some of the finest forests; and its climate varying from sub-tropical to Alpine, with an average rainfall of from 59 in. on the coast to 10 in. in the western interior, is adapted for the pursuit of almost every branch of the pastoral and agricultural industries.

Until lately the colony of Victoria, which has yielded £225,128,056 of gold, has ranked first among the Australian colonies in regard to annual mineral productions; but now New South Wales occupies the premier position, as is shown by the following returns for the year 1889:

New South Wales	£4,761,046
Queensland	2,743,267
Victoria	2,472,962
New Zealand	1,493,167
Tasmania	458,471
South Australia	426,210
West Australia	63,575
Australasia total	£12,418,698

The total value of minerals raised in Australasia, to the end of 1889, is estimated at about £421,398,311.

At the end of 1890, the total value of the minerals raised in New South Wales amounted to £86,685,704. Previous to 1851, the year of the gold discovery, the value of the annual production only reached £720,406; but, during the next ten years, ending 1861, this was increased to £14,997,043; in 1871, to £31,635,617; in 1881, to £55,077,507; and in 1890, to a total of £86,685,704, the value of the yield during the year 1890 being £5,241,514.

In reviewing the above, we must indorse the words of Mr. Harrie Wood, the Under Secretary for Mines, that "such returns cannot fail to show the increasing and national importance of the mining interests of New South Wales."

Practically, this rapid development has taken place since the discovery of gold; for during the forty years of this period, the value of the average annual production has amounted to £2,167,142; while, during the nineteen years previous to 1851—when coal alone was raised—it was only £37,695; and it is interesting to note that each of the four successive decades, from the year 1851, have been marked by the commencement of the development of our principal metallic mines; the first of gold, the second of copper, the third of tin, and the fourth of silver.

During the whole of this period, with but few intervening depressions, the yearly output of coal has been constantly increasing. The other minerals of commercial value are antimony, iron, manganese, chromite, cobalt, bismuth, zinc, tungsten, platinum, asbestos, diamonds and other gem stones; alum-stone, building stones, marble, serpentine, brick and pottery clays, kaolin, ochers, tripolite, roofing slates, and flagging.

I will first refer to coal, as it is our mineral of greatest industrial importance.

COAL.

Coal was discovered in New South Wales in the year 1796, but the value of the quantity raised up to the year 1832 was only £4,194. The value of the total production to the end of 1890 is £24,066,244, the yield for 1890 being 3,060,876 tons, valued at £1,279,088. The coal measures are of the Carbonifero-Permian age, and occupy an area of over 23,000 square miles. There are three principal series which contain workable seams of coal; they have been grouped as the lower, middle, and upper coal measures. The *lepidodendron* beds, which are the equivalent of the English coal measures, occur below these, but there are no workable seams in them. The lower coal measures contain the Greta and West Maitland seams, and consist of plant beds with massive conglomerates, both above and below them, full of marine fauna, *producta, spirifer*, etc., of Carboniferous age. Next in order come the middle coal measures, consisting of fresh water plant beds, embracing the East Maitland coal seams; and above them are the upper coal measures, also plant beds, containing the Newcastle seams. The three series are well developed in the Hunter River coalfield, and *glossopteris* is one of the characteristic fossil plants in each of them. The seams of coal vary from 3 ft. to over 30 ft. thick, containing an aggregate thickness of 130 ft. of coal. These include the seams of coal which are worked in the Newcastle, Maitland, Greta, Singleton, Curlewis, Katoomba, Lithgow, Capertree, Mittagong, Bundanoon, and Illawarra or southern coalfields. But beyond these, in the Talbagarar district to the northwest, the Clarence district to the north, and the Clyde river, or Jervis bay, to the south of Sydney, occur other seams of good coal, not as yet worked, of an aggregate thickness of at least 50 ft. of coal.

Those in the Talbagarar and Clarence district are believed to be of Triassic age. The thickest seam as yet proved is the upper seam in the lower coal measures near West Maitland. In one place it is 32 ft. thick, with only a few bands, and contains the remarkable thickness of 29 ft. of coal. This splendid seam, with two others below it, together contain 41 ft. of workable coal, but they vary in thickness. Mr. T. W. E. David, B.A., F.G.S., Geological Surveyor, through whose survey they were discovered, assumes, for safe calculation, only 15 ft. as the average thickness, and estimates that throughout an area of 20,000 acres occupied by the coal companies, the marketable coal available is worth over £132,000,000 sterling. This area is only a portion of one of our extensive coalfields. The nearest colliery to Sydney is that of the Metropolitan Coal Company, 28 miles by rail south from Sydney, and is working a seam 12 ft. thick. Near the Illawarra railway, in the Jamberoo district, there is a coal seam, which attains a thickness of over 20 ft., as yet unworked. Some anthracite coal is also found in this locality near trap dikes.

The coal of the Hunter River and Curlewis fields is chiefly of a bright bituminous character, yielding up to 40 per cent. of volatile hydrocarbons, and therefore suitable for gas, household, and steam purposes; while that of the western, southwestern, and southern coalfields is less bituminous, but highly esteemed as a steam coal. The upper seam in the Hunter River series, which is worked in the Northumberland colliery, is also of this nature. Excellent coke is produced from them. The seams worked crop out at the surface, or within a workable depth, in numerous localities—some near the principal shipping ports, others in the inland districts, and many are favorably situated for manufacturing industries; the metropolis, Sydney, being especially so, having the principal coalfields surrounding it on the north, west, and south, while it occupies almost the center of a great coal basin, beneath the surface of which, at depths of 2,231 ft. at the Sutherland and 2,600 ft. at Liverpool, as proved by diamond drill borings, the seams have been found to extend. A bore, now 2,100 feet deep, is being put down at Cremorne, on the north shore of Sydney Harbor.

Besides the seams already named, there are other thick seams of good coal containing too many bands for them to be worked in the ordinary way; but if treated by coal-washing appliances, such as the "Luhveg" coalwasher, they could be properly worked, and would prove a great boon, especially to the inland towns, railways, and smelting works. The use of small coal for the manufacture of briquettes will also economize the coal supply; but the sources of supply are practically inexhaustible, as the seams of coal extend under such large areas.

It has been estimated that the New South Wales coal seams which are over 2½ ft. thick and within a depth of 4,000 ft. contain, after allowing one-fifth of their total contents for loss and waste in working, etc., 78,198,200,000 tons of coal—a quantity about equal to that which the coalfields of Great Britain are said to contain.

The present important and increasing intercolonial and international relationship of New South Wales, in regard to the coal trade, is evident from the fact that 35·8 per cent. of the total annual production is exported to the Australian colonies (Victoria alone taking 22·2 per cent.) and 29·4 per cent. to foreign parts, San Francisco, etc.; while the remaining 34·7 per cent. supplies the home consumption. The demand for America is chiefly for the gas coal from the Hunter River coalfield, especially for that of the "Greta" seams in the lower coal measures, which yields to 40 per cent. of volatile hydrocarbons. The large ocean-going steamers generally use the less bituminous steam coals of the Illawarra coal seams.

KEROSENE SHALE.

The middle and lower coal measures contain, in addition to ordinary coal, seams of petroleum oil cannel coal, which vary in thickness up to 5 ft. This remarkable coal, usually called "kerosene shale," is the richest of the kind yet found in the world; and it is interesting to know that the Hon. Sir Saul Samuel, K.C.M.G., C.B., the Agent-General for New South Wales, was the first to work it in the colony. It yields, on analysis, as much as 84 per cent. of volatile hydrocarbons, and produces 150 gallons of crude oil per ton, or 18,000 cubic feet of gas with an illuminating power equal to 40 candles. It has been principally worked for the manufacture of kerosene oil and for mixing with coal, for increasing the illuminating power of the gas made therefrom, at Hartley, Joadja Creek, and America Creek; it occurs also at Katoomba, Megalong, Bathgate, Capertree, Colley Creek, and in several other localities. The best shale realizes about £3 per ton. The value of the shale raised in 1890 was £104,103.

Coal mining may be considered one of the most reliable of the mining industries of New South Wales for the investment of capital, in view of the inexhaustible sources of supply and the rapid industrial progress of the colonies. The output of the coal has been more than doubled within the past nine years, and its average selling price is about 10s. 8½d. per ton.

GOLD.

Gold mining, as is well known, has played a most important part in the history of Australasia. The first recorded discovery of gold dates back to the year 1823; but the actual mining for gold commenced in 1851, and the production to the end of 1890 amounts in value to upward of £330,000,000 sterling, which includes £38,000,000 in New South Wales, £227,000,000 in Victoria, £26,000,000 in Queensland, and over £46,000,000 in New Zealand. The yield during the year 1889 from all the colonies was £6,474,198, of which New South Wales contributed £434,070; and the yield for 1890 was £460,284.

Gold was first obtained from the alluvial drifts, and it was traced up to the reefs, from the degradation of which the greater portion of it was derived, while some has been precipitated from an aqueous solution permeating the rocks and drifts, and some also has been derived from the disintegration of auriferous basalt and other rocks. The auriferous reefs occur traversing Silurian, Devonian, and Carboniferous strata and in granite, porphyry, diorite, serpentine, etc. The drift deposits resulting from the denudation of these rocks are found in the Carboniferan, Permian, Cretaceous, Eocene, Miocene, Pleistocene, and recent formations. In quartz reefs and metalliferous lodes gold is generally found associated with sulphides of iron, copper, lead, silver, zinc, bismuth, arsenic, etc., and in ores resulting from the oxidation of these metals. It is also more or less alloyed with silver, osmo-iridium, and tellurium. The various modes of occurrence of gold afford a wide subject of great interest.

The yield of gold from alluvial deposits is decreasing; but there are considerable areas of country as yet unprospected, and doubtless the "deep leads," not yet worked out, will themselves afford profitable employment to miners for many years to come, such as in the Gulgong goldfield, from which, during the first seven years of its prosperity, 16 tons of gold were obtained. A permanent and increasing supply is anticipated from the numerous unworked gold-bearing reefs, in addition to those which are now being mined.

Hitherto there have been many failures in reef mining, some, if not the majority, of which have resulted from preventable causes, such as mismanagement, want of suitable appliances and ignorance of the modes of occurrence of the gold in the reef. The latter are very important to recognize; for in most instances, the gold occurs, not evenly distributed throughout the reefs, but in irregular patches or "shoots." There are also reefs containing sulphides of iron, lead, zinc, etc., which require special appliances for their treatment, first, as regards concentration of the sulphides, which are often very complex; and, secondly, efficient chemical or other methods of treating them. For working such auriferous ores, New South Wales offers a large field for mining enterprise. The treatment of gold-bearing antimony ores, of which there is likely to be a very large yield in the New England and Macleay districts, is deserving of special attention.

SILVER AND LEAD.

Silver mining in New South Wales has recently attained great prominence. If we take the value of the silver produced in 1889, together with that of the lead, with which it is chiefly worked, the amount—£2,762,554—exceeds that of any of the other mineral products, coal ranking next in value, viz., £1,279,088, or, with that of the kerosene shale added, £1,383,191. The silver lodes traverse Silurian and Devonian strata and the igneous rocks, chiefly granites, which intrude them. The most important lodes yet opened are at Broken Hill, the Pinnacles and Thackaringa, in the Barrier Ranges, Mitchell, and Sunny Corner, Captain's Flat, Lewis Ponds, Cordillera, and Costigon. The ores from several of these yield also a fair quantity of gold. There are numerous other silver lodes—in the Barrier Ranges, Castlereagh, Denison Town, Boorook, Rivertree, Woolombi, and other districts—which command attention. The largest yet worked is the Broken Hill lode, traversing Silurian gneissoid schists, and consisting of gossan and manganese oxide, with carbonates of lead, etc., etc., and sulphides of lead, iron, zinc, copper, and silver; also some native silver. The Broken Hill Company's mine on this lode has yielded, since May, 1886, to November 30, 1890, 20,811,710 ounces of silver from 516,228 tons of ore treated; besides 83,413 tons of lead, the total gross value being £4,757,722. In the Vegetable Creek district the silver lodes contain Fahlerz with sulphides of lead and zinc. At the Sunny Corner mine, during one year, 24,547 tons of ore were furnaced, producing 634,016 ounces of silver and 6,413 ounces of gold; the ores of this locality also contain copper and lead.

Notwithstanding the large and increasing yields from the Broken Hill lode, there is not likely to be an over-production of silver from the various mines; for as the more easily worked oxidized ores in the upper portions of the lodes become exhausted, the cost of treatment of the sulphide ores at the lower levels must increase, but with improved concentrating and reducing appliances, and from the fact that numerous small lodes will also yield considerable supplies of ore, the present annual production of silver is likely to be maintained for some years to come. The introduction of efficient processes for saving the lead, zinc, copper, etc., associated with the silver should also add to the permanence of the industry, and there are considerable tracts of country occupied by the geological formations in which other silver-bearing lodes will probably be found. The silver ores consist chiefly of chloride, chloro-bromide, iodide, and sulphide of silver, with occasionally native silver; these are usually associated with carbonate and sulphide of lead, the lead occurring in such quantity as to be profitably extracted with the silver as silver lead bullion. For instance, from the Broken Hill proprietary mine 516,228 tons of silver ore smelted yielded 83,413 tons of lead. From the Sunny Corner mine, 24,972 tons of ore yielded 201 tons of lead, 309 tons of copper, and 1,256 tons of matte, containing 319,324 ounces of silver, and 2,300 of gold, valued at £74,200. From the Cordillera mine, in the Tuena district, 9,300 tons of ore yielded 227 tons of lead, besides 220 tons of copper, 82,800 ounces of silver, and 404 ounces of gold, valued at £37,343. Then, 500 tons from the Lewis Ponds mine yielded at the rate of 10 per cent. of lead, and 30 ounces of silver and 5 dwt. of gold per ton. Other instances also might be given, for which I will refer to the "Annual Reports of the Department of Mines, Sydney." On account of the silver and lead being worked together, I have referred to them under the one head, and it will be perceived that the production of lead will be large.

TIN.

Tin mining is also one of the important industries of

* Recently read before the Society of Arts, London.

New South Wales. The annual production of tin is nearly equal in value to that of gold, the yield for 1890 being 392,841 tons. The total production to the end of 1890 amounted to £9,255,384. Mining for tin commenced in the year 1871, and the ore obtained has been chiefly stream tin, washed from the alluvial drifts and beds of existing streams, and also from older alluvial deposits in the channels of the streams of the Tertiary and probably Cretaceous periods. These ancient stream deposits are called "deep leads," for they are sometimes buried to a depth of 200 ft. beneath more recent accumulations, including thick flows of basalt. The richest deep leads yet worked are in the New England district, and their fossil flora indicates them to be of Eocene age. In the Vegetable Creek tin fields alone Mr. Geological Surveyor David has mapped out 49 miles in length of "deep leads," of which only about four miles have, as yet, been worked out, yielding very rich returns during the past eighteen years. In the northern, or New England district, the formation containing the tin lodes, from the denudation of which the tin-bearing drifts have been derived, are granite, porphyry, and metamorphosed sedimentary beds of Devonian or lower Carboniferous age; but in the Barrier ranges in the western part of the colony, the tin oxide occurs disseminated through very micaceous granite dikes intruding Silurian gneissoid schists. Owing to the scarcity of surface water in this district, and the patchy occurrence of the tin ore, they have, as yet, not been profitably worked. But, as I believe that large quantities of ore might be raised, yielding up to 5 per cent. tin oxide, and water obtained by conserving the rainfall, if not by sinking, there seems to be no reason why these tin-bearing dikes may not be profitably worked. The granite dike stone is very micaceous, resembling the tin stone from Port Darwin in North Australia, and from Harney Peak in America. For its efficient treatment it will, no doubt, require special crushing and concentrating appliances. In the New England district, the tin lodes have hitherto been very little worked; the principal lode yet opened is "The Ottery," near Vegetable Creek, from which one crushing of 1,200 tons yielded nearly 5 per cent. of tin ore, and other crushings a little over 3 per cent. Lead, copper, bismuth, gold, silver, wolfram, etc., are sometimes found in the lodes. The tin mining industry may be regarded as one of great permanence.

COPPER.

Numerous copper lodes have been opened in the colony. They chiefly traverse Silurian formations, with the exception of the Gordon copper mine, which is in granite, and is partly worked for gold. The largest and most extensively worked lode is that at Cobar, which attains a width of 100 ft. Other lodes have been worked at Thompson's Creek, Mount Hope, Peelwood, Carangara, Wiseman's Creek, Malong, Frogmore, Balara, Blayney, etc. They all consist of gossan with copper carbonates, from the surface downward, until the unoxidized sulphides are met with. Lead, zinc, gold, silver, tin, and bismuth are occasionally met with in the copper ores. Mining for copper commenced in the year 1858. The largest annual production was in the year 1883, and was valued at £557,201. The subsequent low price of copper, together with cost of land carriage to shipping ports, have had the effect of closing some of the mines; but now that the market has improved this industry is reviving, and the output for 1890 realized £173,311. Large quantities of low grade ores exist, which, I believe, might be profitably treated by a wet process, such as that used by the Tharsis Copper Company.

ANTIMONY.

Antimony lodes have been worked in the Macleay, New England, Gulgong, and Crudine districts. They traverse Devonian sedimentary beds in association with granitic dikes. The ore, oxide and sulphide of antimony occurs chiefly in branches in the lodes, thus necessitating very irregular mining operations with uncertain output.

Some years ago, several thousand tons were raised from the Carangula mines in the Macleay district, but, partly owing to the then low price of the metal, the mines were stopped; the recent increase in the value of antimony should now lead to the reopening of these mines. The lodes at Hillgrove are being worked principally on account of gold, but they contain also a large proportion of antimony.

In various parts of the country between Hillgrove and the Nambucca-Bellinger district, gold-bearing antimony lodes have lately been found; so that there is a good prospect of a considerable development in mining for these metals in this part of the colony. At Razor Back the lode, though small, is similar in mode of occurrence. It is to be hoped that an efficient and economical process for extracting gold from these antimony ores will soon be introduced.

IRON.

Another of our sources of future wealth is iron mining, which is in its embyro state of development.

Near Mittagong and Berrima deposits of rich limonite, or brown iron ore, occur in the middle of a coalfield, with limestone not far distant, near Marulan. These deposits, with those near Picton, I have estimated contain in sight about 8,234,000 tons of ore, giving an average yield, on analysis, of about 45 per cent. of metallic iron. In the adjoining Goulburn district there are other deposits of rich ore. Some years ago an attempt was made to work the deposits at Fitzroy, but without success. Recently, however, Mr. A. Brazenall, of Fitzroy, has been smelting the ores on a small scale, and using the iron in his foundry. Smelting works were also established at Lithgow, to reduce the ores of the Lithgow, Wallerawang, and Blayney districts; but these works changed their operations to smelting and rolling old iron. The iron ores available for Lithgow consist chiefly of limotite, occurring as thin irregular clay bands of rich quality in the coal measures, together with more aluminous and silicious ores in shale beds and veins in the overlying Hawkesbury series. Limotite and magnetite, with garnet ore in lodes and irregular patches, near Wallerawang, and patches of rich limonite and magnetite in the Blayney district.

Reports on these have been made by Professor Liveridge, F.R.S., Mr. Carne, F.G.S., and myself. Limestone is abundant on the railway line at Wallerawang.

Mr. Geological Surveyor David, F.G.S., has recently reported on some rich beds of magnetite near Stroud and Muswellbrook, in the vicinity of limestone, and not far from a coalfield. This magnetite, however, contains titanium. He has also reported on the brown hematite deposits near Rylstone, which, with those of the adjoining districts, are estimated to contain 2,226,000 tons of ore, yielding 43 per cent. of metallic iron.

I have estimated that the three principal localities, Fitzroy, Wallerawang, and Rylstone, where coal and limestone are abundant, embrace iron ore deposits, together containing about 12,944,000 tons of ore, capable of yielding 5,853,180 tons of metallic iron.

It would, probably, be advantageous to establish iron or steel works in the Newcastle or the Illawarra coalfields on the coast, where excellent coke is made, and bring the iron ores there from inland, or from the large deposits which are said to exist in New Caledonia.

MANGANESE.

Rich ferro-manganese ores are found in Bendemere, Glanmere, and Rockley districts; also near Goulburn and in the Barrier Ranges. Several hundred tons have been shipped to England; but, as yet, the deposits have not been much worked.

Ferro-manganese, for steel manufacture, might probably be profitably produced in the colony for export.

CHROMITE.

Irregular deposits of chromic iron occur in the serpentine formation at Bowling Alley Point, Bingera, Young, and Gordon-Brook.

COBALT.

Cobalt has been, to some extent, worked in the manganese ores, yielding up to 4 per cent. cobalt at Bungonia; and some rich arsenide ores, containing, according to analysis, up to 13 83 per cent. of cobalt, have been found on private property near Carcoar.

BISMUTH.

Bismuth has been worked to some extent (ore to the value of £36,141 having been exported), chiefly from quartz lodes, at Kingsgate and Hognes Creek, near Glen Innes. It also occurs at Silent Grove, the Gulf, Elsinore, Tenterfield, Adelong, Mount Gipps, near Broken Hill, Gumble, and near Captain's Flat. In the lodes at Kingsgate, pieces of metallic bismuth have been obtained from a few ounces up to 50 lb. in weight.

MERCURY.

Cinnabar (sulphide of mercury) occurs disseminated through Tertiary clays and drifts, and in the underlying slate rocks on the Cudgegong River. Attempts have been made to work it, but, so far, without success. I believe, however, that the deposit could be profitably worked if operated upon in a more systematic manner than it has yet received. Cinnabar has also been recently discovered in Serpentine, near Bingara and Solferino.

ZINC.

Sulphide of zinc has been found in some abundance in the silver lodes at Broken Hill and Castle Rag. I understand there is a ready market for sulphide of zinc at Swansea and Belgium. This mineral is found, more or less, in many of the metalliferous reefs throughout the colony, as at Morurga and Drake.

TUNGSTEN.

Wolfram (tungstate of iron) occurs in some quantity in the bismuth lode at Hognes Creek, near Glen Innes and in a large reef near Emmaville. Schneelite (tungstate of lime) has been found in small reefs near Hillgrove. These minerals have not yet been worked.

PLATINUM.

Platinum has been washed from the auriferous sands on the sea beach in the Richmond River district. If these sands were operated upon on a large scale, the platinum might, I believe, be profitably extracted along with the gold. In alluvial deposits on slate formation near Parkes, platinum has been found in scattered grains with gold, and lately it has been discovered, *in situ*, in ironstone lodes near Orange, and near Broken Hill.

ALUMSTONE.

A large deposit of alumstone, yielding up to 80 per cent. of alum, has been opened at Bullahdelah by the Australian Alum Company. This mineral is to be exported to special works near Liverpool for the manufacture of alum. During 1890, 220 tons were raised, valued at £3,000.

DIAMONDS.

Mining for diamonds was carried on in 1869-1872, on the Cudgegong River, near Mudgee, and near Bingera. Some 10,000 diamonds were then obtained, but the work not proving profitable, was almost abandoned until within the last few years, when further prospecting led to the opening of other extensive deposits in the Capes Creek district, near Inverell, of the same character as those of Bingera. Diamond deposits also occur near Mittagong and Burragong. About 50,000 diamonds have been obtained. In weight they averaged nearly half a carat, though many have been obtained up to two carats in weight. The largest diamond recorded weighed five carats. Many are of the "first water," but in color they are chiefly pale straw yellow; several of pale and dark green, brown and black color have been found. Diamonds occur in the old Tertiary drifts, and in the drifts resulting from the denundation of these. As they have not been found in any formation older than the Tertiary, it has been suggested that they have been formed *in situ* in it, but it is not impossible that they may have been originally derived from highly metamorphosed sedimentary formations, believed to be of Carboniferous age, which have been intruded by granite and extensively denuded in the localities where the diamond drifts occur. I am of opinion that diamond mining will become a profitable industry. In places good results have been obtained by working on a small scale with Hunt's diamond separator, but if the deposits were operated upon with appliances capable of putting through large quantities of the drift, the industry would become established. Besides diamonds, sapphires, beryl, emeralds, topaz, zircon, ruby, amethyst, garnet, tourmaline, and other gem stones have been found in some abundance.

Recently some emerald mines have been opened in New England, where this gem occurs *in situ* with beryl, topaz, and fluorspar, in felspathic lode stuff, at the junction of granite and Devonian sedimentary rocks.

SLATES AND FLAGGING.

Roofing slates and slate flagging of good quality are obtained from the quarries at Milla Nurra, near Bathurst, also near Gundagai, and Goulburn. Splendid sandstone flagging is quarried near Orange, Burrowa, and at Buckingbong, near Narrandera.

BUILDING STONES.

Sydney is specially favored with a very fine building stone which is quarried from the beds of sandstone of the Hawkesbury formation which underlie the city. This great sandstone formation extends for many miles to the northwest, and south from Sydney. The stone is of a light sepia brown color, sometimes white, and samples of it from Pyrmont, of which the Sydney post office is built, have withstood a test of 200 tons pressure. Excellent sandstone is obtained from the coal measures and from the Devonian beds in various parts of the colony. Granite is available in many districts. The gray granite, of which the large polished pillars in the post office and other public edifices and the large pedestal for the Queen's statue near Hyde Park are composed, comes from Moruya. A more beautiful granite, containing large cyrstals of adularia-felspar, is quarried at Montague Island. A very desirable easily worked syenitic granite is quarried at Bouval. Marble occurs in large masses near Wallerawang, Blayney, Marulan, Mudgee, Wellington, Kempsey, Tamworth, and other localities. It varies in color from white, gray, and red to black, and has been chiefly quarried for flooring tiles and mantelpieces.

The Wianamatta shales, and the shale beds in the Hawkesbury series and in the coal measures, afford material in great abundance for almost all kinds of brick and pottery making.

Ochers, suitable for paint manufacture, occur in various parts of the colony.

INFUSORIAL EARTH.

A large deposit of infusorial earth, of Tertiary age, occurs near Barraba, and another deposit, of better quality, has been found near the Warrumbungle Mountains. Some good samples have also been sent from the Menindie district. This earth will probably be in demand for the manufacture of explosives.

From the foregoing, it will be seen that New South Wales possesses numerous minerals of economic value, many of which are already more or less extensively worked, while others are awaiting the employment of labor and capital for their development. The chief of these mineral resources, coal, exists in immense quantity, and, as it is perhaps the most important factor concerning the profitable working of the many industries which will, sooner or later, be established in connection with the development of these resources, we may anticipate the settlement of a very large industrial population in this portion of Australia. And when we consider, in addition to the mineral resources, the vast pastoral and agricultural capabilities of the colony, its unrivaled climatic conditions, and its geographical position on the Pacific seaboard, so favored for commercial intercourse with America, Asia, and other countres, we are assured not only of the future industrial greatness of New South Wales, but also, when federated with the Australian colonies, of her important international relationship.

STILT WALKING.*

WE find stilts in use at present at Namur, a city of Belgium. It appears that Namur was formerly subject to periodical inundations of the Sambre and the Meuse. The streets then became converted into water courses or swamps, and the inhabitants could communicate with each other only by the aid of boats or by walking on stilts. This state of things has been entirely remedied, but the passion for stilt racing and the organization of societies of stilt walkers have been perpetuated to our day.

It is stated that the stilt walkers of Namur in days gone by obtained for their city a most highly appreciated privilege. The governor of Namur had promised Archduke Albert to send to meet him a troop of warriors who should be neither on foot nor on horseback. His kept his promise through the aid of two companies of stiltsmen, who evoluted before the duke. The latter, by reason of the pleasure that the spectacle had afforded him, exempted the city of Namur forever from the tax upon beer. The gratitude of the inhabitants to their stiltsmen, and the passion that the youth of the city has preserved for the sport, may be easily comprehended.

The common use of stilts has been observed by travelers among the aborigines of several of the islands of Oceanica, and especially in the Marquesas on the island of Santa Christina. Here, as elsewhere, the use of stilts is due to a climatic peculiarity. During the rainy season, this island, whose surface is but slightly broken, presents numerous swamps in its lowlands. It is in order to cross these for communicating from one side to the other that the inhabitants have from time immemorial used stilts. Let us note that these stilts of a savage people are infinitely more ingenious and more elegant than those of our peasants of Landes. Stilts from the Marquesas exhibiting designs made by fire, strange sculptures, and a really artistic decoration, are to be seen in the Ethnographic Museum of the Trocadero, and in the Museum of the Marine at the Louvre.

Independently of the reasons of facility of communication that have rendered the use of stilts necessary in certain countries, as we have just seen, the idea of mounting upon high sticks in order to appear taller, or for the purpose of exciting the curiosity of spectators, seems to have presented itself in all times and in all countries.

In masquerades we observe artificial giants—individuals who thus mounted upon stilts are very happy in exciting the wonder of the public. We find giants

* Continued from SCIENTIFIC AMERICAN SUPPLEMENT, No. 821, page 13122.

in the Italian masquerades. Gigan and his wife are one of the attractions of the masquerades of Lille and Dunkirk. Almost everywhere we see Gargantuas and Goliaths, and sometimes Saint Georges and Saint Michaels.

From an acrobatic standpoint, walking upon stilts gives rise to feats of agility easy for the performer and amusing to the spectator. Acrobats upon stilts have been observed in Japan, in China, in the Indies, and even in Oceanica.

The use of stilts is a pastime—an amusement for children. We daily see true stilt races in the public gardens. In the country, the little peasants know very well how to manufacture a fine pair of stilts with forked stems taken from a near-by hedge.

A friend informs me that the collegians of Brive-la-Gaillarde formerly indulged in a very peculiar kind of sport. On holidays they started out in a body mounted upon stilts, in order, they said, to hunt vipers. As a weapon, they were provided with a long rod split at its extremity. The *raison d'etre* of their stilts was naturally to avoid being bitten. In the evening, when they passed through the city on their stilts, each holding at the end of his rod one or two adders that he called asps or black vipers, they caused a sensation. The women and children fled before them, or hastily got within doors to avoid their pranks. (Fig. 1.)

FIG. 1.—COLLEGIANS OF BRIVE-LA-GAILLARDE RETURNING FROM A HUNT FOR VIPERS.

It is a very great pleasure, it appears, for persons mounted upon stilts to try to throw each other down. Every young stiltsman is led to fight, push and upset his colleagues. In our public gardens, at the Luxembourg, for example, where a number of young people amuse themselves with stilts, the scrimmages become so frequent that after the occurrence of an accident, the authorities thought it their duty to make an order forbidding them.

Contests upon stilts seem to have the same attraction for the children of the Marquesas Islands as for our young Parisians. Father Mathias, in the account of his voyage to the Marquesas, in 1745, remarks that contests upon stilts hold the first rank among the pleasures of the Canac children. Upon these stilts, says he, which elevate them three or four feet, they indulge in battles, and loud is the laughter that follows the fall of the awkward.

Everywhere that stilts have been used, contests between the stiltsmen have become a sport. At Namur such contests are traditional and constitute a true national tourney. The combatants form two parties. Each camp, composed of seven or eight hundred combatants, has a captain, officers, a flag, and a cockade. The stiltsmen march to Namur Place preceded by a band of music. Each party occupies one side of the Place, awaiting the signal of battle. (Fig. 2.) The bells ring at random, flags wave from the windows, and a host of curiosity seekers and friends has come to be witness of the *fete*. At a given signal the two camps precipitate themselves upon each other. At the first onset, a large number of combatants fall heavily to the ground, and would remain thus without power to rise and would be in danger of being trampled upon, did not their wives, mother, sisters or friends, who have accompanied them, immediately come to their aid. These lift them with great effort, and sometimes after several fruitless attempts.

The combatant thus put upon his stilts rushes anew into the melee if the fall has not injured him too much. It is unnecessary to say that these sports were sometimes dangerous.

The stiltsmen of Namur, who have given representations before Charles V., Peter the Great and Bonaparte, carefully preserve in their archives, and repeat with pride, these words of the Marshal of Saxony: "If two armies coming into conflict should be animated with as much desperation as the youth of Namur, it would be no longer a battle, it would be a slaughter." Stilts, as a practical means of locomotion, have no longer any *raison d'etre* anywhere. In France, notably, the waste lands of Gascony have been cleared and rendered healthy and are now traversed by roads and railways.

The "tchangues" of Landes are gradually disappearing, and soon, perhaps, the remembrance of them will no longer exist except among the octogenarians of the province, or will be preserved in the collections of popular tradition.—*La Nature.*

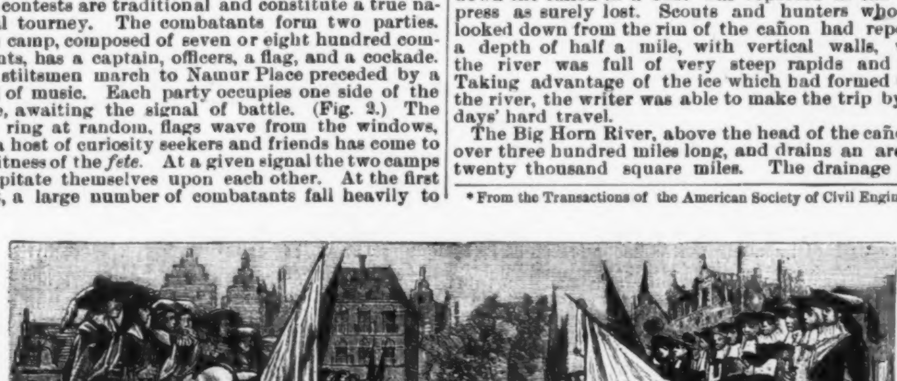


FIG. 2.—ANCIENT BATTLES OF STILTSMEN AT NAMUR.

THE FIRST TRIP THROUGH BIG HORN CAÑON.*

By E. GILLETTE, M. Am. Soc. C. E.

So much has been written respecting our large cañons in the West that it seemed as though there was little left to be told. Having occasion last winter to examine the box cañon of Big Horn River, the writer was much surprised to learn that the cañon had as yet been unexplored. It may be safely stated that this is one of the latest, if not the very last, of our large cañons to hold out against the explorer. This fact alone has induced the writer to consider his explorations in this cañon worthy of special notice. Through southern Montana and northern Wyoming the cañon has had the reputation of being impassable. Anyone who would attempt its passage was considered not in his right mind, and a prospector who ventured part way down the cañon in a boat was reported in the local press as surely lost. Scouts and hunters who had looked down from the rim of the cañon had reported a depth of half a mile, with vertical walls, while the river was full of very steep rapids and falls. Taking advantage of the ice which had formed upon the river, the writer was able to make the trip by five days' hard travel.

The Big Horn River, above the head of the cañon, is over three hundred miles long, and drains an area of twenty thousand square miles. The drainage from this extensive section has cut its way through the limestone sag, between the Big Horn Mountains on the east and Pryor Mountains on the west, forming the formidable box cañon of Big Horn River.

On the morning of the 7th of March, 1891, with blankets for bedding, and provisions for five days tied upon a sled constructed of cotton-wood poles, the writer started with an old Black Hills prospector, by the name of N. S. Sharpe, on his trip through the box cañon. The head of this cañon is four miles south of the crossing of the Montana-Wyoming boundary line, the balance of the 50-mile cañon being situated in the Crow Indian Reservation in Montana. Entering the cañon at the head, we found the river frozen to a depth of 3 feet, but as we journeyed downward open water was encountered at nearly every bend of the river. The cañon almost immediately from the start rises to a height of 500 feet, with vertical walls. At the foot of these cliffs the talus extends from 25 to 100 feet, being at intervals washed away, leaving the cliff perpendicular to the water's edge. The talus stands at an angle of 45 degrees, and supports a growth of cedar trees which find root among the bowlders. The cedar monopolizes most of the cañon, for no other trees grow here save a few cottonwoods at the mouths of side drainages and a scraggy pine or two near the mouth of the cañon.

As we journeyed down the cañon, keeping a sharp lookout for air holes in the ice and glancing at the vertical walls of limestone on each side of us, we began to realize the fact that we were in the box cañon of the Big Horn River, the terrors of which had been so often repeated to us to the measure that "no one had ever gone through the cañon alive." The talus being washed away at the entrance to the cañon as well as at the mouth, "no admittance" stares the pedestrian in the face, no matter from which end he may approach the gorge, and should he succeed in passing these gateways he would soon come to grief at some vertical wall extending to the bottom of the river, while the stream here is making good time down a rapid. This probably has prevented the cañon from being more thoroughly explored up to the present time.

Shortly after entering it we passed under overhanging cliffs which appeared to be striving to meet at the top. These cliffs extend over from the perpendicular 70 to 100 feet, and will form a shed, as the boys said, "for a train of cars on a rainy day." There is ample room under the roof, as the shed towered hundreds of feet above us. Swinging around the bends of the river we soon came to the State line, where we found the balance of our party engaged in running a preliminary line in the cañon to determine its practicability for a railroad route. The men were apparently but a short distance above the river; however, when we had climbed up to them and looked down, we realized that a tumble might result disastrously. We found the transit set up on the edge of a cliff with one leg of the tripod nearly parallel to the plumb line, while the transitman was barely able to maintain his position on the narrow shelving rocks; a misstep of an inch would have precipitated him to the hard bowlders 70 feet below. The chainmen made their way around almost vertical cliffs, hanging on with fingers and toes, and as we gazed at them we thought there is no room here for the fellow who usually "coons" a dangerous spot.

Taking observations on the height of the cañon, we found the vertical wall to be 600 feet, while a slope of 45 degrees rises beyond, a distance of 200 feet more. This order of the cañon, with gradually increasing height, continues for 2½ miles, when we found ourselves at the entrance of Devil's Cañon, where the walls are 1,000 feet high, as determined by triangulation. As we gazed at the small patch of sky visible, and noted the smallness of the few trees up on the rim, we had a faint conception of the immense work the river has performed in cutting this channel through the mountains. The eastern drainage to the cañon comes from the Big Horn Mountains, while from the opposite side the streams drain the eastern slope of the Pryor Mountains. A peculiar feature of the Big Horn Mountain drainage is that these streams coincide with the divides, cutting their way through what appears the most difficult part of the country, completely reversing the position of the larger drainages in almost any other country. Devil's Cañon carries a stream of water from the new gold camp at Bald Mountain, and this stream, as if competing with the river, has formed a grand cañon of its own. Another feature of the cañon is that immediately below the mouth of the larger side drains, the steepest rapids in the river occur. Tracks of otter, wolves, mountain sheep, and occasionally that of a bear, were noticed in the snow.

As we continued down the cañon the walls decreased in height, until at the Sentinel, five miles below Devil's Cañon, they are reduced to a height of 500 feet. The Sentinel is a pillar of limestone, apparently 100 feet or more in height by 20 feet in diameter, and stands upon a point of rocks 300 feet above the river. The writer named the rock, as the thought occurred to him that a sentinel might be imagined to be on duty protecting this beautiful cañon from disfigurement by some advertising agent. Had he with "pot and brush" endeavored to paint any of those well known advertisements seen from any car window in the country, the writer is sure the sentinel would have fired upon him as an enemy to whom no quarter should be given. As night came upon us we went into camp beneath the Sentinel, well knowing we should find him on duty in the morning. From the Sentinel the walls of the cañon vary from 500 to 900 feet in height, vertical, as usual, and apparently no wider apart at top than high. At intervals small streams break through the side walls of the cañon, forming formidable-looking cañons of their own, while from the cliffs above, the smaller drainages, being too weak to cut their way through the limestone, pour their waters over the cliffs, forming innumerable waterfalls 500 feet and more in height. At other places what appears a cave in the wall of the cañon is an outlet for some stream, which, having sunk in a recess back from the cañon, has tunneled its way through the wall, forming smaller cascades of from 200 to 300 feet high. Four miles below the Sentinel, the east wall breaks away, widening the cañon a half mile. Here is found a good ford of the river and a trail leading out of the cañon on both sides; this is about the only opportunity we found of getting into and out of the cañon for its entire length. Several good sized streams come into the cañon from

* From the Transactions of the American Society of Civil Engineers.

the east side, above and below this ford, at the mouths of which gold is found in places, and this appears to be the case all through the cañon, as "colors" were found in every pan of dirt washed out, which had been taken from the bars near the mouth of these streams. At no distant day good placer mines may be found in this comparatively unknown cañon, and quartz mining back in the mountains will receive more attention. A short distance below the ford the cañon closes in again and continues thus for 15 miles, gradually increasing in height as the river approaches the main divide of the Big Horn Mountains. At 15 o'clock of this our second day's trip in the cañon we came to a most noticeable point of rocks, which the writer named the Tower, from its form and commanding appearance. The west wall of the cañon is here pierced by a side drainage coming in nearly parallel to the main cañon, leaving a knife edge or wall between the two streams. This knife edge is broken off vertically at the end, while a little distance back a square niche has been taken out of the edge 200 feet deep and long, leaving a pinnacle on the point towering 700 feet above the river, with an almost vertical slope on all sides. The Tower is one of the many picturesque points in the cañon; every bend of the river, however, reveals something new, and nothing commonplace is found throughout the entire length of the cañon. Four miles below the Tower we made our second night's stay in the cañon. Travel, so far, had been slow, owing to the depth of snow on the ice and the numerous portages we were obliged to make around the rapids, where the river was free from ice. Three miles below this camp, and 36 miles from the head of the cañon, there is a side drainage coming in from the west which splits a sharp point or angle of the cañon's wall, leaving a shell of rock on either side 500 feet high. The gulch is known by the name of Dry Hollow, and gold is found here in paying quantities. In several bars along the cañon and in places formerly the bed of the river, Sharpe panned out enough gold to show that the "diggings would pay."

Three miles below Dry Hollow Creek a sharp bend of the river forms a high sharp point of rocks, bearing down upon us from a height of 1,000 feet. This point, looking as formidable as the bow of an approaching steamer, has been named Steamboat Point.

Three miles from here Dry Head Creek, the largest drainage from the west, empties into the Big Horn, after having cut its way through the rocks and forming a cañon impassable for six miles back from the river. The walls of the cañon continue to grow higher as we work our way down, until at night, forced to camp on a shelf of rock, by an overflow of water on the ice, we gazed up at a cliff 1,200 feet high, and observed by the whirling snow up on the rim that a heavy wind storm was in operation, while there was a dead calm in the cañon. Starting out the next morning at 7 o'clock, we soon passed the mouth of Elk Creek, the third largest stream coming in from the Big Horn Mountains, and here we found immediately below the mouth of this creek a nice level tract of some 80 acres in extent. It is the only smooth ground in the cañon. As we approached Elk Creek the cañon began to widen out, and, rising in terraces, reached an altitude of over 1,000 feet. Here and there ragged points jut out into the cañon, capped with towers and pinnacles, and forming a castellated structure of surpassing grandeur and beauty for the next ten miles, while the river is cutting its way through the divide. This divide is passed five miles below Elk Creek. The lower part of the cañon here consists of a rough rolling country for 600 feet, covered with cedar and a few pines, then rising in broken terraces to the bare divide, more than a half mile above us. Startling a large band of mountain sheep, we watched these animals speeding along the terraces, jumping down short vertical cliffs in what appeared a most reckless disregard for the safety of life or limb, and they finally disappeared up one of the steep side cañons on a well known trail.

Two miles below the divide, Black Cañon forces its way to the Big Horn, and duplicates the cañon of that stream as far as the eye can see. Just below the mouth of the Black Cañon we came to the steepest rapid on the river, where the water at the present time is confined to a narrow bed less than 40 feet wide, the usual width being from 200 to 300 feet. The river continues narrow from here to the mouth of the cañon, and rapids are found at every bend. Innumerable warm springs pour their waters into the river, and we are forced, for want of ice, to abandon our sled and make the balance of the distance down the cañon along the side of the stream.

We camped one more night in the cañon, among huge drifts of wood, 25 feet above the river, and can form a slight idea of how the cañon appears during the season of high water. The walls continue to maintain their lofty height down close to the mouth of the cañon. After a hard day's scramble over bowlders and cliffs we passed through the lower gateway at 16 o'clock, dragging our camp outfit behind us, as the ice here has formed sufficiently to barely sustain our weight. We have had enough cliff climbing for the time being, and are willing to take some chance of breaking through the ice to save another laborious portage. Coming up on to the broad and fertile valley of the Big Horn, it was with a feeling of freedom and satisfaction we made our way down the valley and camp opposite the ruins of old Fort C. F. Smith. Having been confined for five days between those vertical walls of rock, we had no desire to make the return trip up the cañon, especially as of late the weather had been quite warm, and floating cakes of ice showed us that the river was "breaking up." This signified much to us, as it meant longer and more frequent portages. Congratulating ourselves that we at least had "gone through the cañon alive," we started back for camp, over the mountains, having first secured a little flour and bacon to replenish our now empty mess box.

We took the old Sioux trail going back; there was no fear of missing this route, as the Indians have piled up thousands of tons of rocks to mark its course. This trail, which connects the valley of the Big Horn in Montana with that in Wyoming, has been used for centuries by the buffalo and Indian to avoid the big cañon of the river. No Indian cared to venture into its depths, and so this beautiful and comparatively unknown cañon has slumbered on for ages, awaiting the coming of the railroad for which it has cut a deep pass through the mountains, giving an easy grade for the transportation of the products of the country, besides revealing to the traveler probably the finest specimen of a box cañon in the world. We enjoyed the scenery in an almost enthusiastic manner, but could not help thinking that it would appear just as grand and beautiful from the rear platform of a Pullman, or from an observation car, as it did from among the bowlders with a heavy pack upon our back. After three days' wading through the snow we arrived in camp, in good condition to appreciate once more the blessings of full rations and a liberal supply of blankets.

In conclusion, the writer can state that the difficulty and danger of going through this cañon have been, as is generally the case in similar instances, very much exaggerated. When the river is high it would be difficult and unsafe to go through the cañon. Probably the best time of the year to make the trip would be in the autumn, when the water is reasonably low and boats can be used. There are no falls in the river, and but few very steep rapids. He would prefer making the trip in a boat, as in the winter, the ice being quite thin in places, one is liable to break through, when the swift current would take him quickly under the ice. We had an illustration of this above the head of the cañon. A settler was leading two horses across the river on the ice, which suddenly giving way, precipitated both animals into the stream; the current quickly carried them away.

A NEW METHOD FOR THE DISPOSAL OF SEWAGE, WITH SOME REFERENCES TO SCHEMES NOW IN USE.*

By G. G. MOOR, B.A. Cantab.

I.

IN concluding a paper on methods of sewage treatment read at Burlington House at the recent Hygiene and Demography Congress, Dr. Thresh asked this question: "Do any of the processes mentioned, or any combination of such processes, enable us to get rid of our sewage in such a way as to give rise to no nuisance, cause no danger to health, and this at a cost sufficiently reasonable, considering the importance of attaining such results?"

In the opinion of most experts at the present day, the only answer that can be given to this inquiry is an emphatic negative.

We can see this from a brief consideration of those methods that are now in use; they may be divided into three classes:

1. Lime processes.
2. Processes in which lime is not used.
3. Irrigation.

1. The first of these classes may be briefly disposed of; the lime is used either alone or in combination with aluminous salts, or, as in Hanson's process, with the so-called sulphurous powder. In each of these cases a good effluent is the only thing aimed at, as the sludge is worthless.

It is also worthy of notice that where lime has been used to precipitate, it must also be added to press with. Under this head also comes the Amines process, in which herring brine is added to the lime with a view of sterilizing the sewage.

2. *Processes in which Lime is not Used.*—The best known of these is the A B C, in which the sewage is precipitated by a mixture of clay, alum, and charcoal, with a little blood. A clear, inodorous, and tasteless effluent is produced, and the sludge is pressed without lime, dried, and ground; it is stated to contain 3 per cent. of ammonia and 5 per cent. of phosphates; both of these figures seem high if the manure sold has not been enriched by ammonia or phosphate. Much has been said for and against this process; at any rate it is better that the sludge, whatever it contains, should go on the land than have to be thrown away, as sometimes happens in the lime processes.

The International Sewage Purification Company precipitate with a mixture of magnetic oxide of iron and salts of iron, alumina, and magnesia. The effluent is further purified by passing through a filter bed of gravel and polarite. The sludge, when pressed without lime and dried, readily crumbles into a fine powder, and should be of some value as manure.

Webster's Process, or Electrical Treatment.—The sewage travels along a trough in which are placed iron plates connected to the terminals of a dynamo. Water is decomposed, and some iron also passes into solution, precipitation takes place, and the effluent is said to be good.

3. *Irrigation.*—In cases where land is cheap and of suitable character this plan may be adopted with success. In most cases the first cost is great, and so is the cost of maintenance. It is a disputed point as to whether parasites may not be communicated to the animals feeding from the crops raised off unfiltered sewage, and it is certainly not advisable, as is sometimes done, to irrigate fields with untreated sewage, so that pools of purtrefying matter are formed, round which cattle are feeding.

In the case of London it would be practically impossible to get land enough to deal with the enormous volume of sewage, which is very greatly increased in wet weather; and though it may be said that this is in great part rain water, yet the dirt washed off the streets and the fungus torn from the sewers by the increased volume of water will render some method of treatment as necessary as if it were ordinary sewage.

II.

And now to come to the subject of this paper; the treatment I have to lay before you has been practically tested by me at experimental sewage works at Leyton. I have no very novel suggestions as to precipitation of sewage, the originality of my method depending on the manner in which the sludge cake, produced by any precipitation process, may be converted into marketable products.

Let us consider the ordinary composition of sludge cake; it is roughly, in 100 parts:

Water	25
Inorganic matter containing phosphates	20
Combustible matter containing nitrogen	55

* Abstract of a paper read before the British Association, Cardiff meeting, 1891, Section B.

The above figures refer to sludge cake that has been dried by exposure to the air for some days.

Now, suppose we could afford to distill the cake in gas retorts, we should save the ammonia; but it could not pay unless one could produce a sludge very rich in ammonia, and then it would be salable without further treatment. There is, however, a cheaper way of distillation than that I have just mentioned. A Mr. Rees Reece, in a patent a good many years old, described a method of obtaining tar, ammonia, acetic acid, and inflammable gas from peat; this process was in successful operation for some time. He employed a kind of lime kiln with a forced draught, connected to a series of condensers. The operation was conducted in such a manner that the material in the lower part of the furnace was kept in active combustion, its heat distilled the material directly above, and this in its turn gradually descended to serve as fuel for the succeeding charge. Thus nearly the same effect was produced as if the peat had been distilled in retorts, except that, instead of carbonized matter, ash was obtained. I have employed the same method for dealing with sludge cake, and have made experiments on a sufficiently large scale to show the possibility of practical working. A furnace was set up built of boiler plate, lined with brick, and fitted with a fan and condensers; this was kept burning for three weeks continuously, during which time it was fed with sludge cake alone, and this sometimes contained more than 30 per cent. of water, as some came straight from the press. The sludge gives ample heat for its own distillation, and might also be used to raise steam in the same furnace if desired.

The ammonia comes over with the liquor just as in gas works, together with a quantity of light buttery tar which floats on the liquor. The cakes are reduced to a fine ash, which, if the temperature is raised by increasing the blast, can be changed into clinker. A very slight blast is sufficient to distill with, merely enough to get the products of distillation through the condensers.

Now the first question that will suggest itself is: What portion of the theoretical yield of ammonia is actually obtained?

Eighty per cent. was what I actually obtained with the apparatus I had there, and it is at least probable that more could be obtained with better apparatus.

If the blast is carefully regulated, the uncondensed gases will burn, being of similar composition to what is termed "producer gas;" this might be employed in raising steam to drive the fan, pumps, etc., working up the ammonia liquor or distilling the tar. I had originally intended to mix the ammonia, fixed as sulphate with the ash, to form a manure for general purposes; this cannot be done if there is much free lime in the ash, as ammonia is disengaged too readily.

Here, perhaps, I ought to state the reasons which compelled me to give up working at Leyton (where I was treated with great kindness by the authorities). The first reason was the low value of the ash, which contained about 60 per cent. of calcium salts. This great excess is due to the addition of lime first to precipitate and afterward to press with.

The lime also introduces another difficulty, and that is the production of clinker in the furnace. The temperature of the furnace must, of course, be kept up to that point at which inflammable gas is produced, and when this is done it is hard to avoid a certain amount of clinker being formed also.

In the case of some towns where clinker can be used this might be done, and the ammonia alone relied on as a source or income, since sludge cake, even as produced at present, will yield enough ammonia to do more than pay for its distillation in the manner described.

The uncondensed gases from distilling or baking sludge cake have an exceedingly unpleasant smell, and must be burned to avoid creating a nuisance.

Some time ago experiments were made of burning cake made from London sewage in a kind of oven, built with partitions so that the heat from one assists the one next to it, fires being lighted successively. The cake burned without difficulty, but the ash being of little value, it was abandoned. I believe no attempt was made to collect the ammonia.

A few years ago some ovens were tried at Leyton for burning the sludge cake to obtain ash; they either did not attempt or were unable to obtain the ammonia.

There was little or no sale for the ash, and it was subsequently abandoned.

III.

As regards a method of precipitation to go with the method of utilizing sludge cake which I have just detailed:

It is obvious where a separate system is used for storm water the ash will be worth more, as it will not be so contaminated with silica and other mineral substances from the roads.

Of course, what is wanted is a means of producing a sludge cake as rich as possible in ammonia and phosphate, at the same time without adding precipitants in any large quantity which would lower the percentage of phosphate in the ash. At the same time the pressing ought to be done without lime; this is possible, as it is done at Kingston.

I have not been able to make experiments on this subject, but it seems certain that the use of lime ought to be avoided at all costs, and I should be inclined to try carbonized sludge in powder mixed with salts of alumina and iron, after precipitation running the liquid through a bed of lumps of carbonized sludge; when this bed is too foul to use any longer, it can be burned in the furnace.

I was not successful in preparing carbonized sludge in the same furnace that I have spoken of, though I think it could be done in a larger one. The attempt was made to rake out a portion of the sludge after being carbonized, but before it was burnt to ash. At any rate, if this cannot be done the cost of carbonizing sludge in closed retorts heated by the inflammable gases mentioned would not be prohibitive.

It seems probable that by using a sufficient quantity of this carbonaceous material (which can so readily be renewed) a considerable degree of purity could be arrived at in the effluent.

Any seeds present in the sludge, which are sometimes very numerous, are, of course, destroyed in the furnace, and any vegetable matter reduced to ash, so that

potash contained in the solids suspended in the sewage is rendered available.

As to what proportion the resulting manure, if the whole of my scheme were in operation, would be by weight to the cake dealt with, it is not possible to speak with accuracy—it might probably be one-tenth.

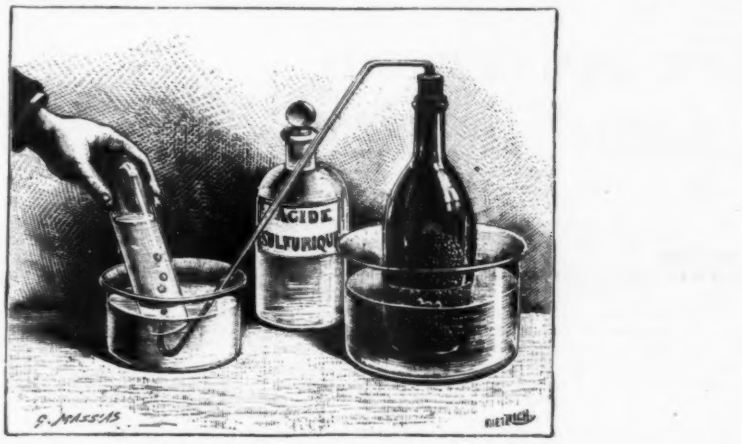
At the present day it is fast becoming widely felt that it is the duty of towns to treat their sewage in some way, so that no injury may be caused to health, yet we surely ought not to rest content with processes which yield nothing but refuse. It is now many years since Liebig insisted on the need of maintaining a proper circulation of phosphates and ammonia if we wish our land to remain fertile, and this need, instead of diminishing, shows itself more clearly every day.

PREPARATION OF HYDROGEN.

IN the country, when it is a question of getting together the elements of the simplest apparatus and mounting them, all sorts of difficulties have to be surmounted. Retorts, balloons, two-necked bottles, etc., all are unknown in a small village, and it is necessary to set one's wits to work to construct his apparatus for himself.

On trying to construct a hydrogen apparatus always ready to operate, and more easily realized in the country than the elegant laboratory apparatus composed of two bottles united by their lower tubulure, I have devised an arrangement that operates very regularly. I have thought that it might perhaps interest some of the readers of *La Nature*.

I take a common quart glass bottle (the bottom of which bulges inwardly), and, with a quick blow struck with the extremity of an iron rod from the exterior to the interior, I pierce the cone forming the bottom. I fill the bottle with zinc filings, and close the mouth with a cork traversed by a glass tube. Then I take a glass vessel (say a jar such as is used by grocers for olives, etc.), having an opening wide enough to allow the bottle to enter freely. I fill the vessel half full of a mixture of water and sulphuric acid, and when the mixture gets cold, I place the bottle in it. The liquid enters through the aperture in the bottom, the zinc is attacked, and the gas escapes through the tube, and may be collected in a test glass, as shown in the figure.



SIMPLE APPARATUS FOR THE PREPARATION OF HYDROGEN.

After the experiment is finished, I remove the bottle and immerse it two or three times in clean water. The zinc, thus freed of acid, is no longer attacked, and may be preserved for a second or third experiment. If, through any accident, the tube should get obstructed, the pressure of the gas would force the liquid into the vessel, and the production of hydrogen would cease.

If the gas is designed for inflating soap bubbles or small goldbeater's skin balloons (but not rubber ones, since the pressure would be inadequate), it will be necessary to free it of humidity. To this effect, it suffices to fill an ordinary lamp tube with quicklime and close its extremities with perforated corks. One of these corks is traversed by the tube issuing from the bottle, and the other by a tube to which may be adapted either the pipe designed to form soap bubbles or the neck of the balloon to be inflated.—*A. Batut.*

THE SEPARATION OF ROSIN FROM FATTY ACIDS.

By E. TWITCHELL, Superintendent of the Emery Candle Co., Cincinnati, O.

THE ethyl ethers of fatty acids, as is well known, are most readily formed by acting on an alcoholic solution of the latter with hydrochloric acid gas, the HCl merely serving to remove the water formed by the combination. This reaction I have found to be practically complete where the alcohol employed is absolute, and the HCl gas is passed to saturation. No other precautions are necessary.

On attempting to etherify rosin acids (common rosin) in the same way, I found that no combination takes place between the alcohol and acid, and that, when the solution is kept cool, the resin acid is entirely unacted on, and can again be separated by diluting with water and boiling to collect the precipitate.

This important difference suggested a method for separating rosin from fatty acids which, on being practically applied, gave me separations such as I think are impossible by any of the methods now in use.

The analysis may be either gravimetric or volumetric, and depends on the fact that, by the means indicated, all the fatty acids are combined to form ethers which are neutral in alcoholic solution and unacted upon by alkalies in the cold, while the rosin is left as it was, reacts acid in alcoholic solution with phenolphthaleine and combines easily with caustic potash to form a soluble soap. It is, therefore, simply necessary to effect the combination of the fatty acids with alcohol, when the resin acids may be titrated with standard NaOH solution, using phenolphthaleine as indicator, or they may be combined with KOH, and the rosin soap thus formed separated from the unsaponified fatty ethers by extracting with naphtha in a separatory funnel.

The gravimetric method is carried out as follows: Two or three grammes of the mixture of fatty acid and rosin are dissolved in ten times their volume of absolute alcohol in a flask, and dry HCl gas passed through in a moderate stream. The flask is set in a vessel with water to keep it cool. The HCl is rapidly absorbed, and, after about forty-five minutes, the ethers separate, floating on the solution, and no more HCl is absorbed. The flask is removed and allowed to stand a half hour longer to insure a complete combination of the alcohol and fatty acid. It is then diluted with about five times its volume of water and boiled until the acid solution is clear, the ethers, with rosin in solution, floating on the top. To this is added some naphtha, and the whole transferred to a separatory funnel, the flask being washed out with naphtha. The acid solution is then run off and the naphtha solution (which ought to measure about 50 c. c.) washed once with water and then treated in the funnel with a solution of 0·5 grm. KOH and 5 c. c. alcohol in 50 c. c. water and agitated. The rosin is immediately saponified and the two layers separate completely. The solution of rosin soap can then be run off, treated with acid, the rosin collected in any manner desired, dried, and weighed. A second washing of the soap with naphtha is hardly necessary, as very little remains after the first extraction. The naphtha used is 74 deg. gasoline, and for this purpose is much to be preferred to ether.

The first stages of the volumetric method are similar to those of the gravimetric, with the exception that the contents of the flask are washed into the separatory funnel with ether instead of naphtha, and the ether solution in the funnel is then thoroughly washed with water, until the wash water is no longer acid; 50 c. c. alcohol, previously neutralized, are then added and the solution titrated with standard NaOH solution. If the combining equivalent of rosin is known, its percentage may be calculated, or some of the original mixture may also be titrated, when the difference in NaOH required will correspond to the fatty acids converted into ether.

I have tested this method by a number of experiments, some of which I will here describe. As a first step it was necessary to determine the effect of HCl gas on alcoholic solutions of fatty and of resin acids separately.

1. Five grms. of distilled fatty acids were dissolved in 50 c. c. absolute alcohol, treated with HCl gas in the manner described, then treated with water, boiled, washed in a separatory funnel, and dried. They yielded 5·451 grm. of ethyl ethers. These ethers were dissolved in neutralized alcohol and titrated with a normal solution of NaOH. They required for neutralization 0·14 c. c. of the solution. This would represent 0·97 per cent. of resin acid, taking 346 as the combining equivalent of rosin, *i. e.*, the weight of rosin neutralized by 1 c. c. normal alkali = 0·346 grm.

2. Five grm. fatty acids from a low grade tallow were treated in the same way, and required 0·06 c. c. for neutralization = 0·41 per cent. rosin.

These figures, although not indicating a perfect combination, are still very small, and I think can be explained, especially in the first case, by the supposition that there were actually some resin acids present, natural constituents of the crude fats.

On attempting to use alcohol of 90 per cent. instead of the absolute, I could only succeed in etherifying 92 per cent. of the fatty acids.

3. Five grm. of an average sample of rosin were treated in exactly the same manner as in working with the fatty acids. After diluting with water and boiling the rosin was collected by dissolving in a little ether and found to weigh 4·9382 grms. This was dissolved in alcohol and required 14·27 c. c. of the NaOH solution to neutralize it. Five grms. of the original rosin were titrated and required 14·45 c. c. There has been a slight loss in drying, but no change in the combining weight.

It was found that if the alcoholic solution became heated by the HCl gas, or if the solution was boiled without first diluting with water, the rosin suffered some change and required less NaOH to neutralize it.

Analyses were made of a number of mixtures. In using the volumetric method the mean combining weight of fatty acids was taken at 275, and of resin 346.

A mixture consisting of 20 per cent. rosin, 80 per cent. f. a. gave, by the volumetric method, 20·36 per cent., 21·40 per cent. and 19·91 per cent. rosin. The same by the gravimetric method: 18·93 per cent. rosin.

A sample of soap said to be made of 100 parts fat to 40 of rosin, and, therefore, containing 28·67 per cent. rosin, assayed by the volumetric method, 73·7 per cent. fatty acid, and by the gravimetric method, 25·7 per cent. rosin.

Unsaponifiable matter in the fat does not affect the process, but can be determined by the volumetric method in one operation, as follows: Two grms. of the original fatty mixture are titrated with normal NaOH solution and saturate a c. c. Two grms. are treated with HCl gas, etc., then titrated and saturate b c. c. Then

$$b \times 0·346 = \text{weight of rosin.}$$
$$a - b \times 0·275 = \text{weight of f. a.}$$

The remainder is unsaponifiable matter.

A mixture of rosin, fatty acid, and paraffine was prepared and analyzed in this manner, with the following results:

	Calculated.	Found.
Rosin	21·3	22·6
Fatty acid	43·6	42·7
Paraffine	35·1	34·7

I have since analyzed a number of samples of soaps and always obtained the rosin distinctly brittle, and, therefore, practically free from fat. This I found to be the case even when the percentage of rosin was so low as 4 or 5 per cent.

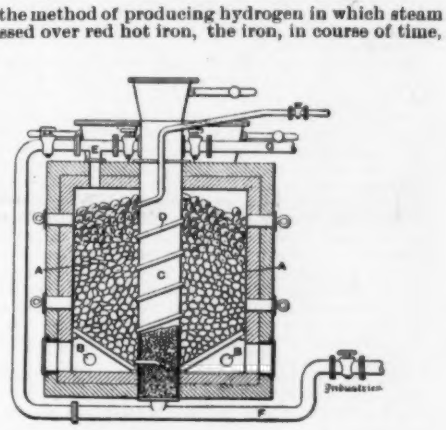
In my experiments the caustic soda solution was normal, but a more dilute solution might be used with advantage, as a smaller sample could be taken and the operation considerably hastened.

The figures given have been those actually obtained, without correction for error, such as unsaponifiable matter in the original rosin, which would affect the gravimetric determination. The volumetric method I should prefer in all cases except where an examination of the rosin was desired.—*Journal Analytical and Applied Chemistry.*

PRODUCTION OF HYDROGEN.

By V. B. LEWES, Greenwich, England.

IN the method of producing hydrogen in which steam is passed over red hot iron, the iron, in course of time,



becomes oxidized, and the process stopped, which necessitates the removal of the oxide of iron and the substitution of fresh iron before the process can be continued. This invention is designed to enable hydrogen gas or a mixture of hydrogen and carbon monoxide in this manner to be carried on in an efficient manner and on a commercial scale by apparatus simpler in construction than hitherto used, and in which the iron is made to serve again and again for the decomposition of the steam. The accompanying illustration shows one form of the apparatus, in which A is the producer fitted with tuyeres B. In the center of the producer is placed the retort C, which may be filled with fragments of iron, or, if a mixture of hydrogen and carbon monoxide be wanted, with a mixture of iron and carbonaceous material. D is a steam pipe exposed to the heat of the furnace so that the steam may be superheated, its upper end being connected to a steam generator while its lower end opens into the retort. E is a pipe for placing the interior of the producer in communication with the top of the retort, and F is another pipe for the escape of gases that have been used to reduce the oxide of iron, and which will consist chiefly of steam and carbon dioxide. G represents the pipe for the delivery of the hydrogen. The operation is as follows: The producer is charged with coke or other carbonaceous material, which is lighted at the bottom. The air blast is then turned on until the fuel is raised to a bright red heat, when a little steam is admitted with the air blast, and the resulting hydrogen, carbon monoxide, and nitrogen produced are led from the producer into the retort, the contents of which latter become highly heated, partly by the heat of the gases and partly by the heat transmitted through the sides of the retort. The gases escape by the pipe F. When the iron oxide is reduced to iron, and the required temperature is obtained, the producer gases are then turned off, and steam is sent through the retort from the pipe D, and hydrogen is generated. When the iron becomes oxidized, the oxide can be reduced back to metallic iron by the producer gases, and the operation continued. Claims: In the manufacture of hydrogen by the decomposition of steam by contact with heated iron, and reducing the resulting oxide of iron to the metallic state for reuse by subjecting it to the action of a reducing gas, utilizing the heat generated by the production of the reducing gas to maintain iron at a temperature at which it will decompose steam and the resultant oxide of iron at a temperature at which it can be reduced by the reducing gas.

CHESTNUT WOOD TANNIN.*

By Prof. HENRY TRIMBLE.

THE *Castanea Vesca* of Linnaeus or *C. Sativa* of Miller, variety *Americana*, is a large tree of rapid growth, found in many parts of the United States, especially in the eastern section from Maine to Delaware, and on mountains as far south as northern Alabama.

An extract of the wood and bark has been prepared in this country and France for a number of years. This extract is especially useful in tanning where it corrects the reddish color of hemlock, and in dyeing where it gives a dead black with salts of iron. It must not be confounded with the extract of chestnut oak, *Quercus Prinus*, Linn., which is also largely manufactured in this country, and, no doubt, the manufacturers are not very particular to keep the two separate.

Most of the literature on the subject of chestnut tannin refers to that from the horse chestnut, *Æsculus Hippocastanum*.

In order to leave no room for doubt about the origin of the tannin described in this paper, the chips, free from bark, were collected from a large tree about forty years old, cut in the month of August.

A summary of the constituents of the wood, as found by a proximate analysis, may be of interest before commencing a description of the tannin:

	Per Cent.
Crystalline wax, melting at 50° C., soluble in hot 95 per cent. and in absolute alcohol	1·03
Gallic acid	0·05
Resin	0·28
Tannin, extracted by absolute alcohol	3·42
Mucilage	1·15
Dextrin	1·89
Sugar	0·96
Tannin, extracted by water	1·92
Pectin and albuminoids	1·46
Extractive, dissolved by dilute acid	2·95
Ash	7·08
Moisture	7·05
Cellulose and lignin	70·76
	100·00

It is not certain that the gallic acid pre-existed in the wood, because it may have been formed during the drying of the chips, since the analysis was not made for some time after they were cut and ground.

A special determination of tannin on a separate portion of the wood by gelatin and alum and by permanganate and hide powder gave, respectively, 7·86 and 7·85 per cent.

The tannin used in the following experiments was prepared by percolating two and one-half kilos of the finely powdered wood with a commercial ether, which consisted of about seventy-four parts ether, twenty-six parts alcohol, and a small quantity of water. The ether was recovered from the percolate by distillation and the residue dissolved in cold water. The filtered aqueous solution was precipitated in three portions by lead oxy-acetate, the precipitates decomposed by hydrogen sulphide, the latter removed by distillation under reduced pressure, and the solution after cooling agitated with ether, which extracted gallic acid from each of the three fractions. The tannin solution from the middle fraction was warmed to remove ether and then saturated with common salt. An abundant separation of tannin took place, which was collected, washed with a saturated solution of salt, and dried over sulphuric acid in a vacuum.

The dry residue was dissolved in ether-alcohol, filtered and rapidly evaporated to dryness under diminished pressure, which left the tannin in a porous, light-red mass. This was used for some of the qualitative tests, but for many of the reactions the tannin was further purified by again precipitating in three fractions with lead oxy-acetate, the lead removed by hydrogen sulphide, the latter removed by distillation under reduced pressure, until the liquid had reached a small bulk, when it was agitated with ether, which removed gallic acid from each of the three fractions. The aqueous solution was then distilled to dryness under reduced pressure, the residue in each case dissolved in ether-alcohol, filtered, and rapidly distilled under the same circumstances to dryness, which left the tannin in a nearly white porous mass completely soluble in cold water.

In physical and chemical properties this chestnut-wood tannin so closely resembled gallotannic acid that the following comparative statement is given to show both the character and resemblance at once:

Reagent.	Chestnut-wood Tannin.	Gallotannic Acid.
Ferrous salts,	No change,	No change.
Ferric chloride	Blue-black ppt.,	Blue black ppt.
and Ammonium hydrate,	Purple ppt.,	Purple ppt.
Tartar emetic	Slight clouding,	Slight clouding.
and Ammonium chloride,	Pale ppt.,	Pale ppt.
Copper sulphate	No ppt.,	No ppt.
and Ammonium hydrate,	Light brown ppt.,	Light brown ppt.
Bromine water,	No ppt.,	No ppt.
Calcium hydrate,	White ppt. turning light blue,	White ppt., turning light blue.
Ammonium molybdate,	Yellow color,	Yellow color.
Sodium sulphide,	No change,	No change.
Con. sulphuric acid,	Light yellow,	Light yellow.
Sulphuric acid (1 to 9),	No deposit,	No deposit.
Lead nitrate,	White ppt.,	White ppt.
Cobalt acetate,	Flesh colored ppt.,	Flesh colored ppt.
Manganese acetate,	White ppt.,	White ppt.
Uranium acetate,	Crimson color, turning dark red,	Crimson color, turning dark red.
Ammonium picrate,	No ppt.,	No ppt.
Potassium bichromate,	Brown ppt.,	Brown ppt.
Ferric acetate,	Blue black color and ppt.,	Blue black color and ppt.
Alkaloids,	White ppt.,	White ppt.
Gelatin,	White ppt.,	White ppt.
Lead acetate,	Light ppt.,	Light ppt.

One per cent. solutions of the tannins were used as recommended by Procter,† and all the reagents were applied in solution except sodium sulphide. These reactions do not all agree with those given by Procter, but he used a solution of commercial extract of chestnut which may have consisted in part or entirely of chestnut oak, or the difference may be due to the non-tannin constituents of the extract.

* Read at a meeting of the Chemical Section, Franklin Institute, June 16, 1891.

† Text-Book of Tanning, p. 112.

The chestnut-wood tannin was found to decompose when heated to 200° C. into pyrogallic and metagallic acids, an abundant crop of crystals being obtained of the former. Each of the three fractions was estimated for sugar and the first found to contain 10·48, the second 7·98, and the third 6·18 per cent. of glucose, which, no doubt, had existed as a glucoside.

The second fraction was dried at 120° C. and submitted to elementary analysis as follows:

1. 0·1170 gramme of substance gave 0·2211 CO_2 and 0 0486 H_2O.

2. 0·0843 gramme of substance gave 0·1575 CO_2 and 0·0363 H_2O.

	1.	2.
C	51·15	50·95
H	4·58	4·79
O	44·27	44·26
	100·00	100·00

On calculating for the presence of 7·98 per cent. glucose and deducting the difference from 1, we get:

	Found.	Calculated for $C_{14}H_{10}O_9$
C	52·11	52·17
H	4·40	3·10
O	43·49	44·73
	100·00	100·00

It will be noticed that the percentage of hydrogen is greater than that in digallic acid, but in view of the fact that it was dried at 120° C. instead of 140° C., as recommended by Lowe,* and that it agrees so closely with gallotannic acid in all its reactions, we cannot but conclude that it is gallotannic acid.

An acetyl derivative was prepared which in many respects resembled pentacetyl tannin, but the figures proving it could not be obtained in time for this paper.

* Zeitschrift fur anal. Chemie, 11, 378.

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TABLE OF CONTENTS.